Edwards Aquifer Authority
2020 Work Plan
## 2020 Edwards Aquifer Authority Work Plan Budget

<table>
<thead>
<tr>
<th>EAHCP Section</th>
<th>Conservation Measure</th>
<th>Table 7.1</th>
<th>Available Budget for 2020</th>
<th>Estimated 2020 Budget</th>
<th>Delta between Available and Estimated</th>
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</thead>
<tbody>
<tr>
<td>5.5.1</td>
<td>ASR Leasing &amp; Forbearance</td>
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<td>$4,759,000</td>
<td>$5,891,594</td>
<td>($1,132,594)</td>
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<td>$1,151,682</td>
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<td>FMA §2.2</td>
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<td>$750,000</td>
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<td>($283,435)</td>
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<td>Science Review Panel</td>
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<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
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<td><strong>Total</strong></td>
<td></td>
<td><strong>$16,151,597</strong></td>
<td><strong>$14,477,082</strong></td>
<td><strong>$12,929,620</strong></td>
<td><strong>$1,547,462</strong></td>
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</table>

a. Expected to change as leases are renewed through 2019 and 2020. Estimate presented based on best available data to date

b. Includes Critical Period Monitoring if required
5.5.1 Edwards Aquifer Authority and San Antonio Water System Aquifer Storage and Recovery Work Plan

Section 5.5.1 of the Edwards Aquifer Habitat Conservation Plan (EAHCP) assigns acquiring leases and options of water permits for use in the San Antonio Water System (SAWS) Aquifer Storage and Recovery (ASR) to the Edwards Aquifer Authority (EAA). SAWS will operate the ASR infrastructure and retain control of day-to-day operations of the ASR facility related to EAHCP water injection and recovery. The EAA will ensure compliance with EAHCP requirements through management of the Interlocal Contract between the EAA and SAWS for the Use of the Twin Oaks Aquifer Storage and Recovery Project for Contribution to Springflow Protection, which became effective August 14, 2013. The contract outlines the responsibilities of both parties, including administration and implementation.

Long-term Objective:
The objective of SAWS Twin Oaks ASR (ASR now run out of H2O Oaks facility) system is to deliver 126,000 acre-feet of Edwards Aquifer groundwater. This water is best managed to offset pumping from Edwards Aquifer wells during a repeat of a drought similar to the drought of record and acquire an additional 50,000 acre-feet of agricultural, municipal, industrial groundwater withdrawal rights to either be made available for physical storing in / crediting to the Regional ASR balance or may be forborne.

Target for 2020:
The ASR contract between EAA and SAWS will continue to be implemented. EAA is the leasing agent for ASR leases and will continue providing SAWS with notices of availability of EAHCP groundwater. As filling nears 126,000 acre-feet, future water acquired by the EAA through contractual agreements with permit holders will be utilized for forbearance purposes during a repeat of a drought of record. During a drought of record, the ASR may be used by SAWS to offset forbearance and an additional 50,000 acre-feet of groundwater will go unpumped by permit holders in the region. In year 2020 the total amount of water available from multi-year leases is 15,924 acre-feet and it is expected that 126,000 acre-feet of EAHCP groundwater will be in storage by the end of the year. Any additional groundwater secured by EAA above this amount will be used to meet forbearance obligations as outlined in the EAHCP.

ASR Program:
Description of the SAWS ASR: The SAWS H2 Oaks ASR is an underground storage reserve in the Carrizo Aquifer in southern Bexar County. As a SAWS water management project, it is designed to store Edwards water when demand is less than available supply. The stored water is returned to San Antonio for use when demand is high and Edwards supply is restricted by Critical Period Management and other drought-related limitations.

The capacity and capabilities of the SAWS ASR are such that it can be used to meet SAWS ratepayer expectations and, if operated as described in the EAHCP, will play a significant role as a Phase I activity to protecting the Covered Species at Comal and San Marcos Springs.

Injection: Storage of EAHCP groundwater shall be at the discretion of SAWS and will be dependent on operating conditions. All EAHCP groundwater made available to SAWS before June 30th, 2020, will be physically stored or credited as if stored, and will be used to meet any forbearance from the Aquifer should triggers defined in the Interlocal Contract occur in 2020.

Forbearance and Recovery: Forbearance of Edwards Aquifer pumping from certain wells will occur when the ten-year rolling recharge average is less than 500,000 acre-feet and the ten-day average of aquifer levels measured at the J-17 index well drop below 630 feet mean sea level (MSL). The annual amount of water to be recovered from the ASR during a repeat of the drought of record is outlined in Exhibits E & F of the Interlocal Contract. Changes to the Presumptive Forbearance Schedule outlined in Exhibit E may be approved as outlined in Section 5.3 of the Interlocal Contract.

Leasing: In 2020 the total amount of water available under long-term leases is 15,924 acre-feet. The amount of groundwater withdrawal rights secured by the EAA is enough water to meet the filling goal of 126,000 acre-feet. In 2018, EAA staff began marketing long-term (ten-year) forbearance agreements with regional permit holders effective in 2019. A total of 14,609 acre-feet in forbearance agreements are still needed in order to have 50,000 acre-feet of groundwater withdrawal rights under EAA control that will remain unused during drought of record conditions.

Monitoring:
The EAA will actively manage the Interlocal Contract with SAWS. Status reports and updates will be provided regularly to the Implementing Committee.

ASR Regional Advisory Group: Per Section 5.5.1 of the EAHCP, a 12-person SAWS ASR Regional Advisory Group will meet to advise SAWS as SAWS makes the decisions relating to the operation of the ASR facility relevant to the EAHCP. Membership on the Regional Advisory Group will include: four representatives from the San Antonio Water System, the EAHCP Program Manager; one representative each from the EAA, EAA permit holder for irrigation purposes, small municipal pumpers, the spring cities, environmental interests, industrial pumpers, and downstream interests.
**Budget:**

Table 7.1:
$4,759,000 – Lease Options
$2,194,000 – O&M
$6,953,000 – Total

2020 available budget:
$4,759,000 – Lease Options
$2,194,000 – O&M
$6,953,000 – Total

Estimated 2020 budget:* 
$5,891,594 – Lease & Forbearance Options
$408,255 – O&M
$6,299,849 – Total

*Actual expenditures for 2020 will be determined by the terms of the Interlocal Contract depending on the quantity of EAHCP groundwater physically stored, the amount of active water leases, and the cost of eligible operation and maintenance activities. Budgeted money that is not spent will be placed in the reserve fund.
5.1.3 Regional Water Conservation Program

Long-term Objective:
To reduce withdrawals from the Edwards Aquifer by 10,000 acre-feet, realized through implementation of conservation measures that will conserve 20,000 acre-feet of water.

Background: Conservation is one of four springflow protection measures of the Edwards Aquifer Habitat Conservation Plan (EAHCP) intended to reduce aquifer withdrawals, and subsequently increase aquifer level and springflow. The concept is to reduce aquifer withdrawals by 10,000 acre-feet and the EAHCP contemplates using a Regional Water Conservation Program (RWCP) to achieve this goal.

In order to provide an immediate benefit to the aquifer and springflow, several entities within the EAA jurisdictional area have agreed to make Initial Commitments to the EAA Groundwater Trust. The initial contribution of 10,000 acre-feet solicited from EAA permit holders was placed in the Groundwater Trust for a period of ten years (Table 1).

The Initial Commitment is returned to the permit holders through the implementation of conservation initiatives and technical assistance provided by the EAHCP. As conservation savings accrue, one-half of the savings are realized by the party participating in the RWCP and the other half is placed in the Groundwater Trust for the remaining term of the EAHCP ITP; allowing the original donors to have their donated water returned on a pro-rata basis. Consequently, 20,000 acre-feet of conservation savings are necessary for full return of the Initial Commitments.

<table>
<thead>
<tr>
<th>Entity</th>
<th>Acre-Feet of Water Donated</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Antonio Water Supply</td>
<td>8,000</td>
</tr>
<tr>
<td>City of San Marcos</td>
<td>300</td>
</tr>
<tr>
<td>Texas State University</td>
<td>100</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>8,400</strong></td>
</tr>
</tbody>
</table>

These Initial Commitments are to be returned to the permit holder at the end of 10 years or when an equal amount is identified as conserved and in reserve by the RWCP. Initial Commitments will be returned to the permit holder in a proportion equal to their contribution.

In late 2015, a specific leak repair program contract 15-780-HCP with SAWS was negotiated and executed, that will fulfill the goal of the 10,000 acre-feet in the EAA Groundwater Trust by 2020 (Table 2). The contract covers the remainder of the ITP and is estimated to conserve almost 20,000 acre-feet accrued over the first five years. The 15-780-HCP contract is an extension of leak repair capabilities. SAWS hires contractors to expand the number of leak repairs that qualify under the agreement, many attributed to SAWS increased vigilant leak detection program funded entirely by SAWS. Regular progress reports from SAWS to EAHCP staff provide number of leaks repaired and an estimate of the overall savings within the time-period of reporting. An annual report is provided to communicate the overall savings realized throughout the year.
Table 2: SAWS – EAA 5-year water savings commitment and fiscal obligation

<table>
<thead>
<tr>
<th>Water</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Savings (AF)</td>
<td>4,745</td>
<td>4,745</td>
<td>4,745</td>
<td>4,745</td>
<td>632</td>
<td>19,612</td>
</tr>
<tr>
<td>Commitment to the Groundwater Trust (AF)</td>
<td>2,372.5</td>
<td>2,375.5</td>
<td>2,372.5</td>
<td>2,372.5</td>
<td>316</td>
<td>9,806</td>
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<tr>
<td>Payment</td>
<td>$4,507,750</td>
<td>$4,507,750</td>
<td>$4,507,750</td>
<td>$4,507,750</td>
<td>$600,400</td>
<td>$18,631,400</td>
</tr>
</tbody>
</table>

With the payment of $950 per acre-foot of water conserved that has been used as a standard for other RWCP participants, the contract will cost $18,631,400. The remaining 9,800 acre-feet will be kept in the Groundwater Trust necessary to complete the 10,000 acre-foot goal.

**Target for 2020:**
With the execution and implementation of the contract with SAWS in 2016, the RWCP will have effectively met its conservation goal in 2020. The Regional Water Monitoring Committee submitted a letter communicating to the Implementing Committee in fall of 2017 the finalization of the RWCP. Effort in 2020 will be to monitor, and report upon, the work SAWS continues to implement in association with their contract with EAA for leak repair.

**Monitoring:**
As part of this contact, SAWS is obligated to transfer to the EAA Groundwater Trust half of the water saved under this program. SAWS will provide a total of three summary reports capturing and quantifying yearly milestones.

**Budget:**
Table 7.1: $1,973,000

2020 available budget: $600,400

Estimated 2020 budget: $600,400
5.1.2 Voluntary Irrigation Suspension Program Option

Long-term Objective:
The goal of VISPO is to enroll 41,795 acre-feet (AF) of permitted irrigation rights (base and/or unrestricted) that will remain unused in years of severe drought based on the approved 2019 minor amendment. Permit holders are enrolled in five-year and ten-year VISPO agreements and will be compensated based on the amount of water enrolled and the program selected. Table 1 below shows the initial payment scale for the five and ten-year VISPO programs. If the water level at the J-17 index well in San Antonio is at or below 635 feet on October 1 of any year, program participants are contractually obligated to suspend the use of their enrolled water for the following year - beginning on January 1.

Table 1: VISPO Enrollment Options

<table>
<thead>
<tr>
<th>Years</th>
<th>Fee</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stand-by</td>
<td>50.00</td>
<td>50.75</td>
<td>51.51</td>
<td>52.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suspension**</td>
<td>150.00</td>
<td>152.25</td>
<td>154.53</td>
<td>156.84</td>
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<tr>
<td></td>
<td>5***</td>
<td>Stand-by</td>
<td>54.00</td>
<td>54.00</td>
<td>54.00</td>
<td>54.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suspension**</td>
<td>160.00</td>
<td>160.00</td>
<td>160.00</td>
<td>160.00</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Stand-by</td>
<td>57.50</td>
<td>57.50</td>
<td>57.50</td>
<td>57.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suspension**</td>
<td>172.50</td>
<td>172.50</td>
<td>172.50</td>
<td>172.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Stand-by</td>
<td>70.20</td>
<td>70.20</td>
<td>70.20</td>
<td>70.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suspension**</td>
<td>210.60</td>
<td>210.60</td>
<td>210.60</td>
<td>210.60</td>
</tr>
</tbody>
</table>

*The amount of each payment escalates at 1.5% annually over the five years of the program.

**Suspension payment is made in addition to stand-by payment.

***5-year program rate beginning 2019.

In year 2018 the total enrollment of 40,921 acre-ft. was sustained. Beginning January 1, 2019, over 9,489 acre-ft. of the 5-year agreements expired including an additional 15,812 acre-feet beginning in year 2020. Beginning May 2018, EAA staff began marketing 5-year VISPO forbearance agreements in an attempt to re-enroll permit holders with expiring VISPO agreements. Table 2 reflects the current distribution of enrolled water and is reflective of new enrollments and any amendments made to VISPO agreements.

Table 2: VISPO Enrolled Water by County

<table>
<thead>
<tr>
<th>Program</th>
<th>Atascosa (AF)</th>
<th>Bexar (AF)</th>
<th>Comal (AF)</th>
<th>Hays (AF)</th>
<th>Medina (AF)</th>
<th>Uvalde (AF)</th>
<th>Total (AF)</th>
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<tbody>
<tr>
<td>5-year</td>
<td>516</td>
<td>665</td>
<td>0</td>
<td>0</td>
<td>2,952</td>
<td>9,671</td>
<td>13,804</td>
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<tr>
<td>10-year</td>
<td>0</td>
<td>1,573</td>
<td>0</td>
<td>0</td>
<td>7,953</td>
<td>6,094</td>
<td>15,620</td>
</tr>
<tr>
<td>Total</td>
<td>516</td>
<td>2,238</td>
<td>0</td>
<td>0</td>
<td>10,905</td>
<td>15,765</td>
<td>29,424</td>
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</table>
VISPO did not trigger on October 1, 2018; therefore, all enrolled water can be used by the permit holders in 2019. Table 3 reflects total payout by year for enrolled water.

<table>
<thead>
<tr>
<th>Year</th>
<th>Payment Type</th>
<th>Total Enrolled (AF)</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>2014</td>
<td>Stand-by</td>
<td>22,388</td>
<td>$1,201,938</td>
</tr>
<tr>
<td>2015</td>
<td>Suspension</td>
<td>40,921</td>
<td>$8,677,262</td>
</tr>
<tr>
<td>2016</td>
<td>Stand-by</td>
<td>40,921</td>
<td>$2,188,500</td>
</tr>
<tr>
<td>2017</td>
<td>Stand-by</td>
<td>40,921</td>
<td>$2,209,000</td>
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<tr>
<td>2018</td>
<td>Stand-by</td>
<td>40,921</td>
<td>$2,228,300</td>
</tr>
<tr>
<td>2019</td>
<td>Stand-by</td>
<td>39,646</td>
<td>$2,320,309</td>
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<tr>
<td></td>
<td>Grand Total</td>
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<td><strong>$18,825,309</strong></td>
</tr>
</tbody>
</table>

Target for 2020:
The effort to re-enroll participants back into the VISPO forbearance program began in year 2018 and will continue throughout 2019. It is expected that EAA staff will re-enroll lost water from expiring agreements and secure up to 40,921 acre-feet by year 2020. Staff will observe the J-17 index well on October 1, 2019 and respond by making payments in a timely fashion and monitor pumping to confirm compliance.

Budget:
Table 7.1:
$4,172,000

2020 available budget:
$4,172,000

Estimated 2020 budget:
$2,508,070
5.1.4 Edwards Aquifer Authority Stage V Critical Period Management

Stage V Critical Period Management was developed and included in the Edwards Aquifer Habitat Conservation Plan to help decrease withdrawals and maintain adequate spring flows at both Comal and San Marcos Springs during times of drought. On February 14, 2012, the Edwards Aquifer Authority (EAA) Board of Directors voted to amend its Critical Period Management (CPM) Program to include the new emergency Stage V. Implementation of Stage V results in a reduction of 44% to municipal, industrial and irrigation permit holders in both pools of the Edwards Aquifer who are authorized to withdraw more than 3 acre-feet per year. Stage V became effective as a rule on March 18, 2013 when the Incidental Take Permit was issued by the U.S. Fish and Wildlife Service.

2020 Implementation:
EAA staff monitors daily aquifer levels in both the San Antonio and Uvalde Pools of the Edwards Aquifer Region, if at any time, the 10-day average for aquifer or springflow levels in either pool reaches the designated trigger for Stage V, the EAA General Manager will issue a Notice of Commencement for implementation in five newspapers within the EAA jurisdiction. Notice will also be posted at the EAA’s office and on the EAA website. All affected permit holders will also be provided written notice of implementation of Stage V and the requirement to reduce pumping by 44%.

Permit Holder Assistance:
The EAA provides an online Critical Period Calculator to assist permit holders in calculating CPM reductions as they apply to each individual permit holder’s total authorized withdrawal amount throughout the year. EAA staff also assists permit holders through “one-on-one” customer service offerings as may be necessary.

Triggers:
The triggers for Stage V in the San Antonio Pool are as follows: the 10-day average at the J-17 index well in San Antonio falls below 625 mean sea level (msl); or the 10-day average at Comal Springs falls below 45 cubic feet per second (cfs); or the 3-day average at Comal Springs falls below 40 cfs. In the Uvalde Pool, Stage V is triggered when the 10-day average at the J-27 index well falls below 840 msl.

Reporting:
By rule, permit holders are required to report their annual groundwater use to the EAA by January 31 for all groundwater used the preceding year. Permit holders who use more Edwards groundwater than authorized annually are subject to enforcement action.
6.3.1 Biological Monitoring Program for the Comal and San Marcos Aquatic Ecosystem

Long-term Objective:
Since 2000, the Edwards Aquifer Authority (EAA) has undertaken biological monitoring of the Comal and San Marcos spring systems. In 2013, the elements of the program were incorporated into the Biological Monitoring Program (BioMP) for the Edwards Aquifer Habitat Conservation Plan (EAHCP).

The purpose of the BioMP is “to monitor changes to habitat availability and population abundance of the Covered Species that may result from Covered Activities” (EAHCP § 6.3.1). The BioMP includes: (1) Comprehensive Sampling, (2) any triggered Critical Period Monitoring, (3) any high flow triggered monitoring (4) and any EAHCP-specific sampling required by Section 6.4.

Target for 2020:
The 2020 BioMP for the Comal and San Marcos aquatic ecosystems will continue to include Baseline and Critical Period Monitoring along with Disturbance impact assessment and overall Take Determinations. The 2020 BioMP will continue to use the standard operating procedures adopted in 2016 as a result of the Biological Monitoring Work Group (EAHCP 2016) in addition to what is noted in this document. These standard operating procedures were instituted for the BioMP beginning in 2017.

Monitoring:

Aquatic Vegetation Mapping: The contractor will conduct aquatic vegetation mapping in the four long-term monitoring reaches in the Comal Springs system and in the three long-term monitoring reaches in the San Marcos Springs system. The comprehensive mapping is conducted using a GPS unit with real-time differential correction with sub-meter accuracy.

Zebra Mussel Monitoring: The contractor will conduct zebra mussel monitoring using passive techniques in both the Comal and San Marcos rivers.

Texas wild-rice Mapping: The contractor will map all Texas wild-rice from Spring Lake downstream to the confluence of the Blanco River on an annual basis. The annual mapping will occur during the summer (July-August). The location of every stand of wild-rice will be recorded using a GPS unit with real-time differential correction with sub-meter accuracy.

Fountain Darter Sampling: The contractor will conduct drop and dip netting and visual aquatic surveys with SCUBA during the Spring and Fall sampling events. Additional dip net sampling will be conducted during the Summer sampling event. Aquatic vegetation will be mapped in the reaches prior to drop and dip net activities.

Drop Net Sampling: Drop netting will be used to sample fountain darters in identified reaches of the rivers in specific aquatic vegetation types that have been selected through stratified random sampling. Fountain darters will be identified, counted, measured, examined for condition and returned to the river at the point of collection. Other fish will be identified and released, or preserved, and identified in a laboratory. Live rams-horn snails will be counted, measured, and destroyed. Exotic Asian snails and Asian clam will be identified, general abundance recorded,
then destroyed. The number of crayfish per drop net will be noted. Furthermore, the vegetation type, height, areal coverage, substrate type, mean column velocity, velocity at 15 centimeters (cm) above the bottom, water temperature, conductivity, and dissolved oxygen levels will be recorded at each location.

**Dip Net Sampling:** The contractor will conduct dip net timed surveys, as well as presence/absence surveys in specified sections throughout the spatial extent of both systems. Fountain darters collected by dip net monitoring will be examined for gill condition. Timed surveys will be conducted in all habitat types within each section, moving upstream during the sampling process, up to a depth of 1.4 m, with prime darter habitat receiving the most effort.

Presence/absence surveys will be conducted by taking 4 dip net sweeps at 50 permanent sample site locations within the 4 representative reaches at Comal Springs (Upper Spring reach [5 locations], Landa Lake reach [20 locations], Old Channel reach [20 locations], and New Channel reach [5 locations]), and the 50 permanent sample site locations within the three representative reaches in San Marcos Springs (Spring Lake Dam reach [15 locations], City Park reach [20 locations], and I-35 reach [15 locations]).

**Visual Fountain Darter Survey:** Visual aquatic surveys will be conducted using SCUBA in a fixed location in Landa Lake to identify fountain darters at depths deeper than conventional sampling methods allow.

**Comal Springs Invertebrate Sampling:** The contractor will conduct sampling for Comal Springs invertebrates during the Spring and Fall sampling events.

One drift net each will be placed over the main spring orifice of Spring Run 1, Spring Run 3, and Spring Run 7 at Comal Springs. All endangered invertebrates will be identified and counted in the field and returned to the orifice they were collected upon completion of the 24-hour sample period. All other invertebrates will be preserved and transported to an off-site laboratory for taxonomic classification. Coordination with the USFWS San Marcos Aquatic Resources Center (SMARC) will take place each time to assist with refugia collections when needed.

The Comal Springs riffle beetle cotton lure standard operating procedure, or a suggested (and EAHCP staff approved) alternate method, and quantitative survey methods will be utilized to conduct Comal Springs riffle beetle sampling in three locations (Spring Run 3, western shoreline of Landa Lake, and Spring Island area). Ten springs within each of the three locations will be identified for sampling by the contractor.

The Comal Springs riffle beetle cotton lure standard operating procedure and cotton lure quantitative survey method allow Comal Springs riffle beetles to be identified, counted, and returned to their spring of origin. Other spring invertebrates collected on the lures will also be noted. These include two other riffle beetles (*Microcyloepus* sp. And *Stenelmis* sp.), Comal Springs dryopid beetles (*Stygoparnus comalensis*), and Peck’s cave amphipod (*Stygobromus pecki*).
In 2018, a Comal Springs riffle beetle Work Group was convened to provide input on a specific set of questions concerning management of the CSRB as part of implementation of the EAHCP. This Work Group may produce recommendations which will modify the current BioMP. A work plan amendment may follow in the latter part of 2019 for inclusion into the 2020 Work Plan.

Salamander Visual Observations: The contractor will conduct salamander sampling during each Spring and Fall sampling event. Comal Salamander surveys will be timed and conducted by observation from the surface or dive mask and snorkel at Spring Run 1, Spring Run 3, Spring Island spring runs, and at the eastern outfall at Spring Island.

San Marcos salamander surveys follow the quantitative sampling method described in Nelson, J. (M.S. Thesis, Texas State University, 1993). Observations for the San Marcos salamander will be done by dive mask and snorkel or SCUBA for three, 5-minute timed surveys per area. San Marcos salamanders will be counted, measured and the overall substrate where they were found documented.

In both systems, sampling will require turning over rocks in the sample site for set periods of time in order to expose the salamanders and obtain a visual count. Whenever possible, all rocks will be returned to their original location. For this monitoring, salamanders will only be observed, and no collections will occur.

Comal Springs Discharge Measurements: The contractor will conduct discharge measurements on Comal Springs during the Spring and Fall sampling events. Discharge measurements will be conducted at Spring Runs 1, 2, and 3, Upper Spring Run Reach, and the Old Channel below Elizabeth Street and will be used to establish the contributions of each major spring run to total discharge in the river and to establish the relative proportion of water flowing in the Old and New Channels.

Water Quality Sampling: The contractor will maintain and download existing thermistors located throughout each system. Standard water quality parameters (water temperature, conductivity compensated to 25°C, pH, dissolved oxygen [mg/l], water depth at sampling point, and observations of local conditions) will be sampled during drop net sampling and fish community sampling activities.

Fixed Station Photography: The contractor will photo document each established, fixed station photograph site. Photographs involve an upstream, across, and downstream picture of the reach and capture key changes in the habitat in the reach.

Macroinvertebrate Community Assessment: The macroinvertebrate community assessment will be conducted using rapid bioassessment (RBA) protocol as described in “Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Assemblage and Habitat Data.” TCEQ RG-416. 2014. The RBAs will be conducted in 5 reaches in the Comal and 4 reaches in the San Marcos at the drop-net fountain darter sites. One composite sample will be collected from each reach (i.e. 9 samples total across both systems). Macroinvertebrate community assessments will be conducted during Comprehensive Sampling and Critical Period Monitoring events.
**Fish Community Sampling:**

**SAN MARCOS SYSTEM**—Fish will be sampled at two locations within Spring Lake associated with San Marcos salamander surveys (Big Riverbed and Hotel Area) and one location just upstream of the eastern spillway. Two different SCUBA techniques will be used to document the fish within the three locations, mesohabitat and microhabitat surveys. Three additional SCUBA survey locations will occur in the San Marcos River (Upper, Mid, and Lower), located in representative deep areas where seining has proven to be inefficient. The exact location of the SCUBA sampling within each section may change slightly based on conditions at the time of the sampling event.

In addition to SCUBA, fish in the San Marcos River will be sampled among five sites within three reaches (Upper: Sewell, Veteran’s Park, Middle: Crook’s Park, and Lower: San Marcos Wastewater Treatment plant and Smith property) via seines within wadeable habitats. Multiple seine hauls will occur along a river transect perpendicular to the flow. Within each seine haul, fish will be identified, measured, examined for disease, and native fish returned to the river. Exotics will be removed from the system as per scientific permit. In addition to fish data, habitat data will be collected for each seine haul including current velocity, water depth, substrate composition, in-stream coverage, climatic conditions, and mesohabitat type.

**COMAL SYSTEM**—Fish will be sampled at three locations within Landa Lake via SCUBA surveys. In particular, one of the SCUBA survey locations in Landa Lake will be in the same as the ongoing fountain darter belt transect survey. In addition, SCUBA surveys will be conducted within the Upper Spring Run, Old Channel, and New Channel sections of the Comal River. Two different SCUBA techniques will be used to document the fish within the three locations, mesohabitat and microhabitat surveys.

In addition to SCUBA surveys, three locations (Upper Spring Run, New Channel, and Old Channel) will be sampled via seines among wadeable habitats to evaluate and track fish populations in the Comal River. Multiple seine hauls will occur along a river transect perpendicular to the flow. Within each seine haul, fish will be identified, measured, examined for disease, and native fish returned to the river. Exotics will be removed from the system as per scientific permit. In addition to fish data, each seine haul will include habitat measurements (i.e. current velocity, water depth, substrate composition, in-stream coverage, climatic conditions, and mesohabitat type).

**EAHCP Habitat Baseline and Disturbance Determination:** This determination is intended to fulfill Section M 1a and 2a of the Incidental Take Permit (ITP).

**DOCUMENT BASELINE HABITAT CONDITIONS**—The contractor will use January 1 of the contract year GIS mapping, biomonitoring data and other existing sources to establish occupied habitat for the EAHCP Covered Species. Specific to Item M (1a and 2a) of the ITP, only occupied habitat within the Comal and San Marcos springs/river ecosystems will be included.

**DOCUMENT EAHCP MITIGATION AREAL EXTENT PER PROJECT**—The contractor will work with staff and contractors from the City of New Braunfels, City of San Marcos and Texas State University, coordinating through EAA staff, to describe in GIS map form, representing a snapshot
in time on December 31 of the contract year, the areal extent of all direct EAHCP mitigation and restoration activities in the Comal and San Marcos springs systems.

If GIS files of the project/affected areas are unavailable, the contractor will either: 1) map those areas directly with high grade GPS in real-time, or 2) use existing areal imagery to pinpoint and outline locations with subsequent, supplemental GPS ground truth mapping. The contractor will ensure that areas represented on all maps are representative of actual mitigation, not concept areas.

Assessment of Net Disturbance: The contractor will evaluate the baseline maps versus the EAHCP project maps and quantify the area of direct disturbance that may have potential effects from mitigation and restoration activities as described in Item M (1a and 2a) of the ITP. The focus will be on quantifying the direct impacts (removal of non-native vegetation, etc.) via areal coverage of habitat, but will also describe potential indirect impacts (turbidity, etc.) qualitatively. This analysis will not extend beyond comparisons of areal coverage of occupied habitat.

Annual "Take" Estimate: The contractor shall estimate Take for each of the Covered Species utilizing the information generated by the BioMP, the information and guidance in Chapters 4 and 6 of the EAHCP, the Biological and Conference Opinion issued by USFWS, and any other relevant information. The purpose of this Take estimation is to ensure compliance with Section H of the ITP.

Critical Period Monitoring: The Critical Period Monitoring component will be performed on both systems and be based upon established flow trigger levels for each system. The type and extent of sampling conducted is dependent on the respective trigger level and is designed to be duplicative of full biomonitoring sampling and will include species-specific sampling based on the flow triggers.

HIGH/LOW FLOW MONITORING—The contractor will conduct high flow Critical Period Monitoring only after the following triggering criteria are met:

a) The daily average flow exceeds 385 cubic feet per second (cfs) in the San Marcos aquatic ecosystem or 500 cfs in the Comal aquatic ecosystem (total flow through the ecosystem as measured at the USGS gauging station located immediately downstream of the ecosystem); and

b) After conducting a joint visual inspection of the aquatic ecosystem with the contractor, EAA staff determines that high flow Critical Period Monitoring is warranted and approved.

Before high flow Critical Period Monitoring is conducted, the sampling parameters must be recommended by the contractor and pre-approved by EAA staff, based on professional judgment, and may include any parameter from the full biomonitoring sampling, with the exception of gill net sampling.

The Comal and San Marcos springs systems flow-based triggers are associated with specific sampling parameters.
SAN MARCOS SYSTEM SAMPLING—Low flow Critical Period Monitoring for the San Marcos River triggers at 120 cfs, with Texas wild-rice vulnerable stand monitoring as described in Task 3 of the Comprehensive Sampling Program. Monitoring will occur at 5 cfs declines or a maximum of once per week. The first Full Sampling Event is triggered at 100 cfs, with subsequent declining Full Sampling Events triggering at 85, 60, 25, and 10-0 cfs for a total of five declining Full Sampling Events. In addition, two recovery Full Sampling Events would be conducted as the system rebounds from the low flow period. Between Full Sampling Events, habitat evaluations, per every 5 cfs decline, would be conducted again not to exceed weekly monitoring.

COMAL SYSTEM SAMPLING— Low flow Critical Period Monitoring for the Comal River triggers at 200 cfs. This triggers the first Full Sampling Event with 4 subsequent Full Sampling Events being triggered at 150, 100, 50, and 10-0 cfs, respectively. Two recovery Full Sampling Events are scheduled as the flows rebound and stabilize from drought conditions. The Comal system also has habitat evaluations scheduled between Full Sampling Events; however, at 10 cfs increments again not to exceed weekly observation. An additional component for the Comal system is the detailed riffle beetle habitat evaluation and spring orifice condition documentation that is triggered at 120 cfs and continued at 10 cfs increments during decline.

A review of historic flow records indicates that the lower the flow, the lower the chance an even lower flow event will occur, thus reducing the chances of a complete decline and recovery as outlined above. Typically, both systems rebound from drought conditions due to a tropical depression rainfall event or some other weather pattern that produces a large amount of rainfall over the watershed. Flows typically come up rapidly and require a period of stabilization before the collection of biological data is meaningful.

Gill Net Evaluation: In addition to the full sampling activities, the contractor will conduct gill net evaluations in the immediate vicinity of the fountain darter SCUBA surveys in Spring Lake and Landa Lake. The Spring Lake evaluation will be triggered at 85 cfs and lower triggers. The Landa Lake assessment will be triggered at 100 cfs and lower triggers. The survey is designed to examine exotic fish concentrations and stomach content analyses with respect to predation of listed species. The number of each species (native and non-native) collected in the gill net and the data will be recorded and converted to catch per unit effort.

Water Quality Grab Sampling: The contractor will collect water quality grab samples at the established triggers at 18 stations longitudinally distributed in the San Marcos system and 12 stations longitudinally distributed in the Comal system. The samples will be from the surface, mid-depth and near bottom.

EAHCP Low Flow Sampling: To protect the Covered Species, Chapter 6 of the EAHCP contains specific flow requirements for both systems that trigger sampling events. This sampling is in addition to the Comprehensive Sampling and Critical Period Monitoring components and consists of an increased frequency of sampling for aquatic vegetation, Texas wild-rice mapping, as well as additional sampling of fountain darters, Comal Springs riffle beetles, and salamanders.
**Budget:**

Table 7.1:
$400,000

2020 available budget:
$400,000

Estimated 2020 budget:
$755,774*

*Includes Critical Period Monitoring if required
5.7.2 Water Quality Monitoring Program Strategy for Comal Springs and San Marcos Springs

Long-term Objective:
This work plan details the sampling strategy and protocols for surface water quality monitoring in 2020 for the Edwards Aquifer Habitat Conservation Plan (EAHCP) (Section 5.7.2) implemented by the Edwards Aquifer Authority (EAA), utilizing a third-party contractor. The goal of the water quality monitoring program, first implemented in 2013, is to detect water quality impairments that may negatively impact the listed species. If certain constituents of concern are detected at levels indicating the potential for adverse effects, the Implementing Committee members with jurisdictional authority will be consulted to identify sources and consider best management practices (BMPs) to reduce and/or eliminate the constituents of concern. If necessary, additional testing could be included in the current or following year to assist in determining the source of contamination and the Science Committee could be consulted to assist with BMP identification and source determination.

Target for 2020:
In 2015, the EAHCP received the National Academy of Sciences (NAS) Report 1 (2015) containing recommendations for EAHCP’s Monitoring, Modeling and Applied Research programs, including the Expanded Water Quality Monitoring Program. From Report 1, a list of water quality monitoring recommendations was presented to the NAS Recommendation Review Work Group (NAS Work Group). Based on the NAS Work Group assessment, at its February 18, 2016, meeting, the Implementing Committee convened the 2016 EAHCP Expanded Water Quality Monitoring Program Work Group (WQWG) to carry out a holistic review of the Expanded Water Quality Monitoring Program, considering the recommendations of NAS, the NAS Work Group, the input of the Science Committee, the Permittees, and subject matter experts. The purpose of the WQWG was to produce a final report for review by the Implementing Committee, developed through a consensus-based decision-making process. The WQWG held meetings from March to May 2016. This work plan reflects inclusion of the changes recommended by the WQWG.

For 2020, the contractors will use the same sampling locations used in 2017 as shown in the attached Figures 1 through 4. However, changes in springflow, surface water runoff, land use, site security and access may dictate minor modification to sample collection locations and schedules as sampling efforts progress. Any minor changes resulting from these factors that are necessary because of safety or equipment concerns will be noted in the field sample sheets and dedicated field books. Should logistics or safety issues require any significant changes to this work plan, the sampling contractors shall report those issues to the EAA. Subsequently, the EAA will present those changes to the Science and Implementing committees for review and approval as needed prior to their implementation.
Monitoring:

*Comal Springs:* Comal Springs discharges an average of about 290 cubic feet second (cfs) into Landa Lake, located within the city of New Braunfels, Texas. Comal Springs is considered a spring complex with multiple discharge points along the 4,500-foot reach of Landa Lake. The springs issue from the Edwards Group limestone along the 4,500-foot section of the northeast-southwest trending escarpment formed by the Comal Springs Fault. Landa Lake forms the headwaters of the Comal River which flows approximately two miles before entering the Guadalupe River.

Discharge measurements have been collected from Comal Springs since 1933, and the EAA has been collecting water quality samples for more than ten years. EAA collects samples from Spring 1, Spring 3, and Spring 7 on a biannual basis during normal flow conditions and more frequently when dictated by research interests. Spring 1, Spring 3, and Spring 7 discharge into Landa Lake and make up part of the Comal Springs complex. Figure 1 indicates these historical groundwater sampling locations. Water quality samples are collected and analyzed for field parameters including dissolved oxygen (DO), pH, conductivity, temperature and alkalinity\(^1\). Samples are also submitted to an EAA contracted laboratory for analysis of cations, anions, nutrients, metals, VOCs, SVOCs, herbicides and pesticides, bacteria, TOC, PCBs, and phosphorous.

**SAMPLING METHODS**—All samples will be collected following the EAA’s *Field Sampling Plan* or contractor’s established methodology upon approval by the EAA. Samples shall be analyzed by a laboratory accredited by the National Environmental Laboratory Accreditation Program (NELAP). No requests to deviate from the EAA’s *Field Sampling Plan* have been received or approved to date.

**SURFACE WATER PASSIVE SAMPLING**—Passive samples are to be collected during the 2020 sampling effort using a passive diffusion sampling device. Devices will be obtained from Amplified Geochemical Imaging LLC (AGI) or be equivalent to AGI devices in functionality and parameters available for analysis. Sample locations for passive diffusion samples (PDS) in Figure 1 are Upper Springs (near Bleiders Creek), Upper Landa Lake (near Spring Island), Lower Landa Lake (above outfalls), Upper Old Channel (Elizabeth Street), and USGS Gauge (above San Antonio Street Bridge).

The passive sampling effort shall be performed in February, April, June, August, October, and December. The devices shall be installed for a two-week interval at the same locations as the sediment samples. When conducting passive sampling events, the contractor will also sample for pharmaceutical and personal care products using a Poly Organic Chemical Integrative System (POCIS) at the most downstream sample site (U.S. Geological Survey [USGS] gauge above San

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\(^1\) Field alkalinity analysis will be conducted within seven days of sample collection.
Antonio Street Bridge). The parameter set for PDS is listed in Table 1 and the parameter set for POCIS is listed in Table 2.

![Comal Water Quality Sampling Map](image)

**Figure 1. Comal System Groundwater Sampling Locations, Passive Diffusion Sampler (PDS) and POCIS Sampling Locations, and EAA Real-Time Water Quality Station Locations**

**Table 1. Analytical Parameters for Passive Diffusion Samplers (PDS)**

<table>
<thead>
<tr>
<th>Parameter</th>
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<td>PDS devices are to be placed at the locations listed Figures 2 and 6, for a two-week time period in the months of February, April, June, August, October, and December.</td>
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<tr>
<td>PDS devices will be from Amplified Geochemical Imaging, LLC, or equivalent and shall provide analyses for the following: TPH, BTEX, 1,3,5 and 1,2,4-trimethylbenzene, MTBE, phenanthrene, naphthalene1-methyl naphthalene, octane, cis and trans-1,2,-dichloroethene, 1,1-dichloroethane, chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, carbon tetrachloride, trichloroethene, tetrachloroethene, chlorobenzene, 1,4-dichlorobenzene, 1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,3-dichlorobenzene, and 1,2-dichlorobenzene.</td>
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Table 2. Analytical Parameters for Poly Organic Chemical Integrative Samplers (POCIS)

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<tr>
<th>POCIS diffusion samplers are to be placed at the locations listed Figures 1 and 3, for a four-week time period in the months of February, April, June, August, October, and December.</th>
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<tr>
<td>17-a-Estradiol, 17-a-Ethynylestradiol, 17-b-Estradiol, Diethylstilbestrol, Epitestosterone, Estriol, Estrone, Progesterone, Testosterone, Bisphenol A, Diclofenac, Gemfibrozil, Ibuprofen, Iopromide, Naproxen, Salicylic Acid, Triclosan, Acetaminophen, Amoxicillin, Atenolol, Atorvastatin, Azithromycin, Caffeine, Carbamazepine, Ciprofloxacin, Cotinine, DEET, Diazepam, Fluoxetine, Galaxolide (HHCB), Meprobamate, Methadone, Oxybenzone, Phenytoin (Dilantin), Praziquantel, Primidone, Quinoline, Sucralose, Sulfamethoxazole, TCEP, TCPP, TDCPP, and Trimethoprim</td>
</tr>
</tbody>
</table>

**STORMWATER SAMPLING PROGRAM**—One stormwater sampling event will be performed in 2020 to evaluate stormwater and runoff quality from the urban landscape. A stormwater sampling event will be triggered when the flow rate at the USGS Comal Springs gauging station (#08169000) above San Antonio Street Bridge increases by 5% or if there is a 20% change in three of the five water quality parameters measured in the downstream real-time water quality monitoring probe. Five samples will be collected at Upper Springs (near Blieders Creek) and New Channel (below confluence with Dry Comal Creek) with the remaining sites sampled only three times (Figure 2). Sampling times will be spaced to reflect changes in the stream hydrograph (one to three during initial rise or first flush, one at peak flow and one during the recession limb).

Stormwater samples will be analyzed using the methods found in Table 3 with duplicate samples as describe in Table 4.

**SEDIMENT SAMPLING**—The contractor will conduct one sediment sampling event at each of the PDS sampling locations (Figure 1). Three samples will be collected at each sample site and composited into one sample for analysis. Sediment samples will be analyzed for the parameters shown in Table 5.

**FISH COMMUNITY SAMPLING**—Fish collections from the Comal River system will be conducted during odd numbered years in conjunction with routine Biological Monitoring sampling so no collections will occur this year.
Figure 2. Comal System Stormwater Sampling Locations
### Table 3. Analytical Parameters for Assessing Water Quality—Even Years

#### Analyses

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<thead>
<tr>
<th>Volatile Organic Compounds (VOCs)</th>
<th>Semi-volatile Organic Compounds (SVOCs)</th>
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<td>Organochlorine Pesticides</td>
<td>Polychlorinated Biphenyls (PCBs)</td>
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<td>Organophosphorous Pesticides</td>
<td>Herbicides</td>
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#### Method

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<td>Polychlorinated Biphenyls (PCBs)</td>
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<tr>
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#### Protocol References:

- EPA = US Environmental Protection Agency
- SW846 = Standard Methods For The Examination Of Water And Wastewater”.

### Table 4. Number of required QA/QC Samples for Stormwater and Sediment Sampling

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<th>QA/QC Samples (Duplicates/EQ Blanks)</th>
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<tr>
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Table 5. Analytical Parameters for Assessing Water Quality from Sediment Sample Locations

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<td>SM 2540C</td>
<td>Alkalinity</td>
<td>SM</td>
</tr>
<tr>
<td>Solids, Total Suspended (TSS)</td>
<td>SM 2540D</td>
<td>Solids, Total Suspended (TSS)</td>
<td>SM</td>
</tr>
</tbody>
</table>

Protocol References:
EPA = US Environmental Protection Agency
SM = “Standard Methods For The Examination Of Water And Wastewater”.

REAL-TIME INSTRUMENT WATER QUALITY DATA LOGGING PROGRAM—Continuous water quality monitoring stations will continue in 2020 at Upper Spring Run, Spring Run 3, Spring 7, Old Channel, and New Channel (below confluence with Dry Comal Creek) (Figure 1).

Monitoring will be performed using a data logging sonde capable of collecting data on 15-minute intervals. The parameters measured will include temperature, dissolved oxygen, pH, and specific conductivity. These data will be evaluated to identify short-term and long-term water quality variations of the spring system as well as changes in water quality related to stormwater runoff. This monitoring effort will continue to be performed by EAA staff in 2020.
San Marcos Springs: Located in San Marcos, Texas, on the campus of Texas State University, San Marcos Springs discharges an average of about 175 cfs into Spring Lake. The springs issue from the Edwards Group limestone along the northeast-southwest trending escarpment formed by the San Marcos Springs Fault. Spring Lake forms the headwaters of the San Marcos River. Discharge measurements have been collected from San Marcos Springs since 1957, and the EAA has been collecting water quality samples for more than ten years.

EAA collects water quality samples from Deep Spring and Hotel Spring at least biannually, with more frequent sampling based on specific research interests. Both Deep and Hotel springs are in the bed of Spring Lake and make up part of the San Marcos Springs complex. Figure 3 indicates the locations of spring sampling at San Marcos Springs. Water quality samples are collected and analyzed for field parameters including dissolved oxygen (DO), pH, conductivity, temperature and alkalinity\(^2\). Samples are also submitted to the EAA contract laboratory for analysis of cations, anions, nutrients, metals, VOCs, SVOCs, herbicides and pesticides, bacteria, TOC, PCBs, and phosphorous.

SAMPLING METHODS—All samples will be collected following the EAA’s Field Sampling Plan or contractor’s established methodology upon approval by the EAA. Samples shall be analyzed by a NELAP accredited contract laboratory. To date, no requests to deviate from the EAA’s Field Sampling Plan have been received or approved.

SURFACE WATER PASSIVE SAMPLING—Passive samples are to be collected during the 2020 sampling effort using a passive diffusion type sampling device. Devices will be obtained from AGI or be equivalent to AGI devices in functionality and parameters available for analysis. Sample locations for PDS samples are Sink Creek, Spring Lake, Sessoms Creek, City Park, Rio Vista Dam, IH-35 reach, and Capes Dam/Willow Creek (Figure 3).

The passive sampling effort shall be performed in February, April, June, August, October, and December. The devices shall be installed for a two-week interval at the same locations as the sediment samples. Each passive sampling effort will also include a POCIS placed only at the most downstream sample site (Capes Dam/Willow Creek). The parameter set for PDS samples is listed in Table 1 and the parameter set for POCIS is listed in Table 2.

\(^2\) Field alkalinity analysis will be conducted within seven days of sample collection.
STORMWATER SAMPLING PROGRAM—The contractor will perform one stormwater sampling event each year. A stormwater sampling event will be triggered when the flow rate at the USGS San Marcos Springs gauging station (#08170500) increases by 5% or there is a 20% change in three of the five water quality parameters measured in the downstream telemetered real-time water quality monitoring probe. Three stormwater samples will be collected from each stormwater sampling location during a stormwater sampling event with the exception of Sessom and Sink creeks where five samples will be collected (Figure 4). Sampling times will be spaced to reflect changes in the stream hydrograph (one to three during initial rise or first flush, one at peak flow and one during the recession limb). Stormwater samples will be analyzed for the parameters listed in Table 3 with duplicate samples as describe in Table 4.
SEDIMENT SAMPLING—The contractor will conduct one sediment sampling event at each of the PDS sampling locations (Figure 3). Three samples will be collected at each sample site and composited into one sample for analysis. Sediment samples will be analyzed for the parameters shown in Table 5.

FISH COMMUNITY SAMPLING—Fish from the San Marcos River system will be collected during odd numbered years in conjunction with routine Biological Monitoring sampling, so tissue sampling will not occur in 2020.

REAL-TIME INSTRUMENT WATER QUALITY DATA LOGGING PROGRAM—Continuous water quality monitoring stations will operate in 2020 at the USGS gauging station (Aquarena Springs Drive), Rio Vista Dam, and Texas Park and Wildlife Department Fish Hatchery (Figure 3).

Monitoring will be performed using a data logging sonde capable of collecting data at 15-minute intervals. The parameters measured will include temperature, dissolved oxygen, pH, and specific
conductance. These data will be evaluated to identify short-term and long-term water quality variations of the spring system as well as changes in water quality related to stormwater runoff. Continuous water quality monitoring stations will be operated and maintained by EAA in 2020.

**Water Quality Monitoring Reporting:** The contractors will compile and present sampling results in an annual report to the EAA. The report will include an evaluation of analytical data, discussions of results that exceed comparative or regulatory standards, a discussion of water and sediment quality, laboratory reports and field data sheets, photographs, sampling locations and rationale, description of sampling methods, and a description and rationale for any deviations from the Water Quality Sampling Plan due to logistics or safety issues. The report is to be submitted electronically and will be reviewed internally by EAA.

**Data Compilation, Analyses and Reporting:** Data collected as a result of the 2020 EAHCP Water Quality Monitoring Plan will be compiled and analyzed, and the results will be presented to the Implementing Committee by February 15, 2021; prior to inclusion in the annual EAHCP Annual Report, which is required by Sections 6.2.4 and 9.3 of the EAHCP and Section 11.1c of the Implementing Agreement. The report will include an evaluation of all analytical data, including graphs, key photographs and general summary of results.

Funding is requested for maintenance and replacement needs for existing real-time instruments, as well as data transmission and web hosting fees. A detailed budget for the real-time instruments is listed in Table 6. Table 7 presents estimated costs for other water quality monitoring.

This 2020 Water Quality Work Plan will be reviewed by the Science Committee prior to implementation. The Science Committee will be asked to confirm the need for additions or changes to this Water Quality Work Plan.
Table 6. Estimated Costs Real-Time Water Quality Monitoring at Comal and San Marcos Springs for Operation and Maintenance

<table>
<thead>
<tr>
<th>Task</th>
<th>Comal Springs (Five Stations)</th>
<th>San Marcos Springs (Four Stations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One new Eureka Manta+ Probe (equipped to monitor Dissolved Oxygen, Temperature, pH, and Specific Conductance)</td>
<td>$7,000</td>
<td>$7,000</td>
</tr>
<tr>
<td>Maintenance Costs for repairs and supplies (calibration standards, batteries, etc.)</td>
<td>$9,500</td>
<td>$9,500</td>
</tr>
<tr>
<td>Emergency funds</td>
<td>$2,500</td>
<td>$2,500</td>
</tr>
<tr>
<td><strong>Comal Springs Total =</strong></td>
<td><strong>$19,000</strong></td>
<td><strong>San Marcos Springs Total = $19,000</strong></td>
</tr>
</tbody>
</table>

**Grand Total = $38,000**

Table 7. Estimated Costs for Water Quality Monitoring at Comal and San Marcos Springs

<table>
<thead>
<tr>
<th>Task</th>
<th>Comal Springs</th>
<th>San Marcos Springs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater Runoff Sampling</td>
<td>$69,332.00</td>
<td>$83,704.00</td>
</tr>
<tr>
<td>Surface Water Passive Diffusive Sampling</td>
<td>$29,911.50</td>
<td>$37,759.50</td>
</tr>
<tr>
<td>Sediment Sampling</td>
<td>$16,105.00</td>
<td>$22,548.00</td>
</tr>
<tr>
<td>Fish Tissue Sampling</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>Meetings, Presentations, and Reporting</td>
<td>$16,525.00</td>
<td>$16,525.00</td>
</tr>
<tr>
<td><strong>2020 Total =</strong></td>
<td><strong>$131,873.50</strong></td>
<td><strong>$160,536.50</strong></td>
</tr>
<tr>
<td><strong>Grand Total =</strong></td>
<td><strong>$292,410.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

Budget:

Table 7.1: San Marcos Springs water quality monitoring and protection (EAHCP § 5.7.2 and 5.7.6): $100,000
Comal Springs water quality monitoring (EAHCP § 5.7.4): $100,000

2020 available budget: $200,000

Estimated 2020 budget:
Real-time Instruments (RTI): $38,000 (Table 6)
Other Water Quality Monitoring: $292,410 (Table 7)

Justification for Budget Adjustment: The real-time water quality data logging instrumentation is in need of funding for maintenance, in addition spare instrumentation is needed to prevent...
extended down time in the event of catastrophic failure. The instruments also require funding for calibration fluids, batteries, and other incidental costs. Cost details are provided in Table 6. Other water quality monitoring costs are consistent with previous years based on the parameters developed through past work groups and committees.

6.3.3 Ecological Modeling

Long-term Objective:
The development of a mechanistic ecological model (Ecomodel) is assigned to the Edwards Aquifer Authority (EAA) per section 6.3.3 of the Edwards Aquifer Habitat Conservation Plan (EAHCP). The purpose of the Ecomodel is to evaluate potential adverse effects to Covered Species and their critical habitat, and to the extent such effects are determined to occur, quantify their magnitude and develop alternate strategies.

Target for 2020:
No Ecological Modeling work is anticipated in 2020.

Budget:
Table 7.1
$25,000

2020 available budget: $0

Estimated 2020 budget*: $0

*There is no proposed budget for 2020.
6.3.4 Applied Research

**Long-term Objective:**
Applied research added a valuable component to Phase I of the EAHCP to better understand the ecological dynamics for all Covered Species.

**Target for 2020:**
Savings from Phase I will be applied to perform research to support a better understanding of existing Conservation Measures and collect data to support efforts to define biological goals for the next Incidental Take Permit expected in 2028.

*A cotton lure applied research study will be performed in 2020 at the recommendation of the Comal Springs riffle beetle Work Group.*

**Budget:**

*Table 7.1:*

$0

2020 available budget:
$250,000

Estimated 2020 budget:
$250,000*

* $1,995,506 remains from the Table 7.1 Phase I budget. $1,995,506 divided over 8 years, the time remaining in the current Incidental Take Permit is roughly $250,000.
5.1.1 Refugia

The U.S. Fish and Wildlife Service’s (USFWS) San Marcos Aquatic Resources Center (SMARC) and Uvalde National Fish Hatchery (UNFH) will provide refugia, salvage, reintroduction, and monitoring services in fulfillment of the Refugia Contract (Contract # 16-822-HCP) between the Edwards Aquifer Authority (EAA) and the USFWS.

This annual work plan and associated cost estimate have been developed per the requirements of contract number 16-822-HCP for the Implementation of the Refugia Program under the EAHCP. The tasks and subtasks that follow provide the details for the services to be performed in 2020, which provide for the maintenance of a refugia population of the Covered Species (Table 1) including the salvage, propagation, and restocking of the species, if species-specific habitat triggers occur and species are extirpated, plus research conducted on the Covered Species.

Table 1: Eleven species identified in the EAHCP and listed for coverage under the ITP

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>ESA Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fountain darter</td>
<td>Etheostoma fonticola</td>
<td>Endangered</td>
</tr>
<tr>
<td>Comal Springs riffle beetle</td>
<td>Heterelmis comalensis</td>
<td>Endangered</td>
</tr>
<tr>
<td>San Marcos gambusia</td>
<td>Gambusia georgei</td>
<td>Endangered*</td>
</tr>
<tr>
<td>Comal Springs dryopid beetle</td>
<td>Stygoparnus comalensis</td>
<td>Endangered</td>
</tr>
<tr>
<td>Peck’s Cave amphipod</td>
<td>Stygobromus pecki</td>
<td>Endangered</td>
</tr>
<tr>
<td>Texas wild-rice</td>
<td>Zizania texana</td>
<td>Endangered</td>
</tr>
<tr>
<td>Texas blind salamander</td>
<td>Eurycea rathbuni</td>
<td>Endangered</td>
</tr>
<tr>
<td>San Marcos salamander</td>
<td>Eurycea nana</td>
<td>Threatened</td>
</tr>
<tr>
<td>Edwards Aquifer diving beetle</td>
<td>Haideoporus texanus</td>
<td>Petitioned</td>
</tr>
<tr>
<td>Comal Springs salamander</td>
<td>Eurycea sp.</td>
<td>Petitioned</td>
</tr>
<tr>
<td>Texas troglobitic water slater</td>
<td>Lirceolus smithii</td>
<td>Petitioned</td>
</tr>
</tbody>
</table>

*The San Marcos gambusia was last collected in the wild in 1983 and may already be extinct.

Long-term Objective:

Background: Section 5.1.1 of the EAHCP requires the EAA to provide a series of refugia, with back-up populations, to preserve the capacity for these species to be re-established in the event of the loss of population due to a catastrophic event.

The concept of refugia is to house and protect adequate populations of the Covered Species and to conduct research activities to expand knowledge of their habitat requirements, biology, life histories, and effective reintroduction techniques. Actions and funding contained within this work plan will be limited to the Covered Species listed in the EAHCP and those associated species that have significant impact on the Covered Species such as predators, competitors, pathogens, parasites, food, cover, and shelter.

2020 Assumptions:

As work plans are developed almost a year prior to implementation, it is possible that methods described herein may be contingent on the status of the current year’s activities or authorization from the EAHCP process. If conditions change, this work plan may need to be amended to
accommodate realized outcomes.

- Target numbers for the standing and refugia stocks to be housed at both the UNFH and SMARC are established by the USFWS-EAA Refugia Contract (Contract # 16-822-HCP).
- Species capture rates are expected to be similar to historic values.
- Mortality rates of specimens held in captivity are expected to be similar to historic values.
- Target species collection numbers from the 2019 Work Plan are expected to be reached.
- Staff members remain employed at the two Service facilities throughout the performance period.

**Target for 2020 Task 1. Refugia Operations:**

*Standing Stocks:* The existing stocks at the SMARC and UNFH will be considered standing stocks under the executed contract (Contract # 16-822-HCP) and will be held in Service facilities until EAA specific Refugia and Quarantine facilities are complete and functional. USFWS staff will take all appropriate steps to collect and maintain standing/refugia stocks at their respective target captive population size in order to provide refugia for all the Covered Species. Table 2 displays the target species numbers.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fountain Darter (Comal)</td>
<td>1000</td>
<td>1000 including specimens within the standing stock</td>
<td>2000</td>
<td>2500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Fountain Darter (San Marcos)</td>
<td>1000</td>
<td>1000 including specimens within the standing stock</td>
<td>2500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Texas Wild-Rice</td>
<td>430</td>
<td>430 including specimens within the standing stock</td>
<td>1500</td>
<td>215</td>
<td>215</td>
<td>150</td>
<td>215</td>
</tr>
<tr>
<td>Texas Blind Salamander</td>
<td>500</td>
<td>500 including specimens within the standing stock</td>
<td>500</td>
<td>110</td>
<td>#</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>San Marcos Salamander</td>
<td>500</td>
<td>500 including specimens within the standing stock</td>
<td>500</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Comal Springs Salamander</td>
<td>500</td>
<td>500 including specimens within the standing stock</td>
<td>500</td>
<td>80</td>
<td>115</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>Peck's Cave Amphipod</td>
<td>500</td>
<td>500 including specimens within the standing stock</td>
<td>500</td>
<td>250</td>
<td>250</td>
<td>160</td>
<td>250</td>
</tr>
<tr>
<td>Comal Springs Riffle Beetle</td>
<td>500</td>
<td>500 including specimens within the standing stock</td>
<td>500</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>Comal Springs Dryopid Beetle</td>
<td>500</td>
<td>500 including specimens within the standing stock</td>
<td>500</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Edwards Aquifer Diving Beetle</td>
<td>500</td>
<td>500 including specimens within the standing stock</td>
<td>500</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Texas Troglobitic Water Slater</td>
<td>500</td>
<td>500 including specimens within the standing stock</td>
<td>500</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

# We will not be collecting Comal fountain darters until we have a better understanding of their mortality rates.
*catch rates and hatchery survival are uncertain given the rarity of the species
Collection: In 2020, we will collect Covered Species as required to reach and maintain target standing and refugia stock numbers as shown in Table 2. Species collections will be coordinated with other ongoing EAHCP activities (e.g. Biological Monitoring Program) so that collections for refugia do not adversely impact other efforts. Species specific collections will be carried out through a variety of passive and active collection methods. Prior to collections, Hazard Analysis Critical Control Point (see Appendix A of the 2017 EAA Work Plan) will be conducted to minimize aquatic invasive species transfer. Collection efforts will be documented and reported to EAA. Captured specimens will be divided between the SMARC and UNFH facilities in order to ensure redundancy and to expedite the obligation to establish and maintain two refugia populations at separate locations. All species will be held in respective quarantine areas until their health has been assessed. Once it is determined that specimens are free from pathogens, parasites, and invasive species they will be incorporated into the general refugia population. USFWS will share reports, including test results, produced as part of the quarantine process. Species-specific collection plans generally follow those detailed within the 2019 Work Plan; however, collection efforts vary based upon collection and knowledge gained during the previous year’s collection efforts. The following sections briefly describe planned 2020 collection, maintenance, and propagation efforts for each species.

Fountain Darters:

COLLECTION—Fountain darters in 2020 will be collected from the San Marcos River primarily in coordination with the Spring and Fall Biomonitoring events to create efficiencies and reduce habitat disturbance. After fountain darters are collected via drop nets for biomonitoring, USFWS staff will retain them for refugia purposes. Specimens will be collected along a longitudinal gradient. Fish will be collected proportionally from the three sections of the San Marcos (upper = Spring Lake, Middle = Spring Lake dam to Rio Vista dam, lower = below Rio Vista dam to Capes dam). Historically, approximately 20% of the fountain darters collected annually succumb to natural mortality. If unusual mortality events occur, they will be thoroughly investigated, and summary reports will be conveyed to the EAA as part of the monthly reports. As a result, fish collections will target additional fish so that as individuals perish the remainder within the captive population should not decrease below the target number between collection events.

Due to the detection of largemouth bass virus (LMBV) in Comal fountain darters throughout the Comal River, all fountain darters from Comal will be maintained in quarantine facilities in consideration of other species located on the two stations. Higher mortality rates of incoming Comal fountain darters have increasingly caused concern as the mortality continues and no root cause has been pinpointed despite extensive testing and evaluation with the USFWS Fish Health Unit. We will conduct exposure trials of non-LMBV+ F1 fountain darters to LMBV+ darters to determine the infection rates and if the non-LMBV+ fish exhibit the same mortality rates. This will be the first step in investigation of the high mortality rates. We will also consult with veterinarians on potential treatments (not already tried) to reduce incoming mortality rates. The next steps would include determining if LMBV is vertically transferred to offspring, the feasibility of producing a population of F1 fountain darters from the remaining non-LMBV Comal fountain darters, and evaluating the mortality rate of Comal fountain darters in the wild. Until we have a better understanding of the high mortality rates of incoming Comal fountain darters we will suspend collections from the wild, unless salvage is needed.

As part of quarantine procedures, a subset of fish (N = 60 per river) will be sent to the southwest regional Fish Health Unit or equivalent facility for pathogen (bacteria, virus, and parasite) testing
prior to specimen incorporation into the general refugia population following standardized methods outlined within USFWS and AFS-FHS (2016) and AFS-FHS (2005); reports will be provided to EAA.

**MAINTENANCE**—Water quality (i.e., temperature, pH, dissolved oxygen, total dissolved gasses) will be monitored and recorded weekly. Fountain darters will be fed live foods reared or purchased. Ponds will be utilized to produce zooplankton and amphipods. Amphipods will be collected from other managed ponds and raceways. Black worms will be purchased when necessary along with other food resources (i.e. blood worms, brine shrimp, etc.) if the need arises. Food items are not routinely examined for pathogens. However, if they are suspect and tested for pathogens all diagnostic results will be conveyed to the EAA within monthly reports.

**PROPAGATION**—Standing and refugia stocks for each river will be maintained to produce F1 generation fish for research purposes. Fish will be maintained by their geographical locations. If reintroduction is warranted, subsets from each geographical location will be communally spawned. Subset groups will be culled to an equal number of progeny prior to release.

**Texas wild-rice:**

**COLLECTION**—Texas wild-rice tillers will be collected from San Marcos River reaches (Fig. 1), with a break during summer months when wild-rice does not fare well due to heat stress. In 2020 collections for SMARC will target stands that are not already part of the refugia population or require supplementation. Collections for UNFH will continue to build their refugia numbers and representative locations. The refugia populations will reflect the wild populations in both their respective proportion and genetic diversity that was historically documented within San Marcos River (Wilson et al. 2016). During tiller collection, the GPS coordinates, area coverage, and depth of the stand or individual plant will be recorded so the exact location of the clone is known. For larger stands, tillers will be collected at the beginning, middle and end of the stand, or every 20% of the stand’s total length for the largest stands. Tiller collection will be done by wading and SCUBA diving. Please note that during the 2018 Texas wild-rice survey no plants were found in Section I. Sections J and K were not surveyed. Plants were found in sections E, G, and H. All sections will be re-evaluated during the 2019 Texas wild-rice survey.
MAINTENANCE—Once tillers have been successfully rooted they will be tagged and maintained so that their collection location is known.

PROPAGATION—Plants will be maintained so sexual reproduction does not occur within the refugia population, unless EAHCP triggers occur. If reintroduction is warranted, seeds and tillers from each geographical location will be produced. Plants produced from seeds and tillers would be transplanted back within their original geographic location.

Texas blind salamanders:

COLLECTION—Texas blind salamanders will be collected through the use of nets and traps. Traps will be deployed quarterly for approximately 12 consecutive days with traps checked every 2-4 days to collect Texas blind salamander individuals from Primers Fissure, Johnson’s well, Rattlesnake cave, and Rattlesnake well (Table 3). To avoid oversampling these habitats, only 1/3 of salamanders observed from each of these locations will be collected during quarterly sampling events. Salamanders will also be collected from a driftnet on Diversion Springs in Spring Lake fished throughout the year during times when we are not actively trapping in caves and wells. Specimens from this site will all be kept, given the assumption that any Texas blind salamander leaving a spring orifice that enters a stream or lake environment will ultimately succumb to predation. These sites will be checked for specimens up to three times per week when applicable. All specimens will be transported live and maintained in the SMARC or UNFH refugia. Drift nets on Sessom Creek and Texas State University Artesian Well are generally checked by Texas State University staff, live Texas blind salamanders are transferred to SMARC according to their permits. USFWS staff may periodically check nets on these sites when they are not being checked.
MAINTENANCE—Specimens will be marked by collection location. As part of quarantine procedures, all salamanders of each species will be non-lethally cotton swabbed, unless they are too small to be swabbed, then, we will do a representative batch swab of group housed salamanders when they are large enough to be safely swabbed. These samples will be processed at SMARC to screen for Batrachochytrium dendrobatidis (Bd, commonly referred to as chytrid fungus) and Batrachochytrium salamandrivorans (Bsal) prior to specimen incorporation into the general refugia population. Duplicate swabs will be retained in case further testing is warranted. Chytrid testing will occur in batches where groups of five swabs will be pooled for analysis. Duplicate individual swabs will be retained in case further testing is warranted. All salamanders will be held in quarantine for at least 30 days and until test results have returned. Chytrid (Bd) fungus has caused mortalities in amphibian species; however, some species appear to have innate immunity. Previous tests of wild caught salamanders at SMARC (both Texas Blind and San Marcos) have almost always tested positive for Bd. Clinically, the salamanders appear normal and do not have any lesions or signs of disease. Positive testing for Bsal will be treated more cautiously as it has not yet been documented in this area (or anywhere in North America); these salamanders would remain in quarantine until further study and recommendations from FWS Fish Health. Salamander tank and system maintenance such as acid washing and system sterilization will occur annually or as needed to ensure proper system function. Water quality will be monitored and recorded weekly. Salamanders will be fed live foods reared or purchased. Ponds will be utilized to produce amphipods. Amphipods will be collected from other managed ponds and raceways. Black worms will be purchased when necessary along with other food resources (i.e. blood worms, brine shrimp, etc.) if the need arises.

PROPAGATION—Standing and refugia stocks will be maintained to encourage reproduction. Salamanders will be marked with visible elastomers, coded by their geographical locations. All progeny will be maintained separately by generations. If reintroduction is warranted, an attempt will be made to produce offspring from each geographical location.

San Marcos salamanders:

COLLECTION—San Marcos salamanders will be collected up to quarterly from below Spring Lake dam and with SCUBA teams in Spring Lake (Table 3). The drift net on Diversion Springs will be checked routinely and specimens will be kept from this location as space in quarantine and need allows. Collection efforts will be coordinated with the EAHCP Biological Monitoring Program. All specimens will be transported live and maintained in the SMARC and UNFH refugia. Historically, approximately 30% of the San Marcos salamanders collected annually succumb to natural mortality. As a result, salamander collections will target additional specimens so that as individuals perish the remainder within the captive population should not decrease below the target number between collection events.

MAINTENANCE—As part of quarantine procedures, representatives of group housed salamanders in quarantine will be non-lethally cotton swabbed. These samples will be processed at SMARC to screen for Batrachochytrium dendrobatidis (Bd, commonly referred to as chytrid fungus) and Batrachochytrium salamandrivorans (Bsal) prior to specimen incorporation into the general refugia population. Duplicate swabs will be retained in case further testing is warranted. Chytrid
testing will occur in batches where groups of five swabs will be pooled for analysis. Duplicate individual swabs will be retained in case further testing is warranted. All salamanders will be held in quarantine for at least 30 days and until test results have returned. Chytrid (Bd) fungus has caused mortalities in amphibian species; however, some species appear to have innate immunity. Previous tests of wild caught salamanders at SMARC (both Texas Blind and San Marcos) have almost always tested positive for Bd. Clinically, the salamanders appear normal and do not have any lesions or signs of disease. Positive testing for Bsal will be treated more cautiously as it has not yet been documented in this area (or anywhere in North America); these salamanders would remain in quarantine until further study and recommendations from FWS Fish Health. Salamander tank and system maintenance such as acid washing and system sterilization will occur annually or as needed to ensure proper system function. Water quality will be monitored and recorded weekly. Salamanders will be fed live foods reared or purchased. Ponds will be utilized to produce amphipods. Amphipods will be collected from other managed ponds and raceways. Black worms will be purchased when necessary along with other food resources (i.e. blood worms, brine shrimp, etc.) if the need arises.

**PROPAGATION**—Standing and refugia stocks will be maintained to encourage reproduction. All progeny will be maintained separately by generation. If reintroduction is warranted, pair-wise and group mating will be employed to produce offspring. Stocking will occur once juveniles have reached 30 mm total length.

**Comal Springs salamanders:**

**COLLECTION**—Comal Springs salamanders will be collected up to quarterly from Comal Spring Runs 1-3 and Spring Island and surrounding areas (Table 3) by hand with dipnets using snorkelers. Close coordination with the EAHCP biological monitoring program will take place to ensure that to the degree practicable, refugia collections do not overlap with specific EAHCP long-term monitoring locales. In the event overlap of sampling areas is unavoidable, Comal salamanders for refugia will be collected at a rate of no more than 10% of salamanders observed in those specific locales per daily sampling trip. A SCUBA team will be used for a portion of these collection efforts if necessary. Annual natural mortality will be recorded.

**MAINTENANCE**—As part of quarantine procedures, **representatives of group housed salamanders in quarantine** will be non-lethally cotton swabbed. These samples will be processed at SMARC to screen for *Batrachochytrium dendrobatidis* (Bd, commonly referred to as chytrid fungus) and *Batrachochytrium salamandrivorans* (Bsal) prior to specimen incorporation into the general refugia population. **Duplicate swabs will be retained in case further testing is warranted.** Chytrid testing will occur in batches where groups of five swabs will be pooled for analysis. Duplicate individual swabs will be retained in case further testing is warranted. All salamanders will be held in quarantine for at least 30 days and until test results have returned. Chytrid (Bd) fungus has caused mortalities in amphibian species; however, some species appear to have innate immunity. Previous tests of wild caught salamanders at SMARC (both Texas Blind and San Marcos) have almost always tested positive for Bd. Clinically, the salamanders appear normal and do not have any lesions or signs of disease. Positive testing for Bsal will be treated more cautiously as it has not yet been documented in this area (or anywhere in North America); these salamanders would remain in quarantine until further study and recommendations from FWS Fish Health. Salamander tank and system maintenance such as acid washing and system sterilization will occur annually or
as needed to ensure proper system function. Water quality will be monitored and recorded weekly. Salamanders will be fed live foods reared or purchased. Ponds will be utilized to produce amphipods. Amphipods will be collected from other managed ponds and raceways. Black worms will be purchased when necessary along with other food resources (i.e. blood worms, brine shrimp, etc.) if the need arises.

PROPAGATION—Standing and refugia stocks will be maintained in gender-mixed groups to allow for reproduction. All progeny will be maintained separately by generation. If reintroduction is warranted, pair-wise and group mating will be employed to produce offspring. Stocking will occur once juveniles have reached 30 mm total length.

Comal Springs riffle beetle:

COLLECTION—Comal Spring riffle beetle collections for standing and refugia stocks will occur four times a year from a variety of locations: Spring Runs 1, Spring Run 3, Western Shore, and areas surrounding Spring Island (Table 3). Riffle beetles will be collected with cotton lures following EAHCP standard operating procedures (Hall 2016). No specific spring orifice will be sampled two times in a row. All riffle beetle adults and larvae will be collected from the lures. Standing stock numbers will be reduced to 75 per station until propagation methods are refined and better knowledge of population numbers and meaningful standing stock numbers are derived. Standing stock number will be evaluated yearly by the Comal Springs riffle beetle Work Group. Additional collections for research purposes may be required outside of standing stock collections.

MAINTENANCE—Specimens will not be maintained by collection location. Comal Springs riffle beetles will be maintained within custom built aquatic holding units and fed detrital matter and matured biofilms colonized on cotton lures.

PROPAGATION—Propagation methods for this species are being developed.

Peck’s Cave amphipod:

COLLECTION—Peck’s Cave amphipod collection for standing stock will occur up to four times annually (Table 3). Adult Peck’s cave amphipods will be collected with drift nets and by hand collection at variety of locations (drift nets: Spring Run 3, N = 2; Spring Island and associated Spring Lake habitats: hand collection). Special collection events will occur in January, February, and March for 2020 research purposes at UNFH, but will be counted towards standing stock numbers, the fourth collection event for UNFH will be in November. During these special collections SCUBA divers will be utilized to collect by hand at deeper locations so collections can be spread out. SMARC will collect amphipods in March, June, September, and December.

MAINTENANCE—Specimens will not be maintained by collection location. Peck’s Cave amphipods will be maintained within custom built aquatic holding units and fed commercial flake fish feeds.

PROPAGATION—Propagation methods for this species are being developed as part of standard refugia operations.
Comal Springs dryopid beetle:

**COLLECTION**—Comal Springs dryopid beetles will be collected primarily through the use of wooden lures and hand picking from submerged wood found in the Comal Spring system. If dryopid beetles are found on cotton lures used for Comal Spring riffle beetles they will also be retained (Table 3). We will potentially conduct two events of trapping in Panther Canyon Well during the year as access to the well and staff time allows. These will be bottle traps checked weekly for a month.

**MAINTENANCE**—Specimens will not be maintained by collection location. Comal Spring dryopid beetle will be maintained within custom built aquatic holding units and fed detrital matter and matured biofilms colonized on cotton lures.

**PROPAGATION**—Propagation methods for this species are being developed as part of normal refugia operations and research projects.

Edwards Aquifer diving beetle:

**COLLECTION**—Drift nets will be used to collect Edwards Aquifer diving beetle (Table 3). Drift nets will be set at a variety of locations where the species has been collected in the past (Texas State University Artesian Well \( N = 1 \); and Diversion Springs \( N = 1 \)). Drift nets will be deployed and checked by USFWS staff when we are able to sample Texas State University Artesian Well (when not being used by Texas State staff).

**MAINTENANCE**—Specimens will not be maintained by collection location. Captured specimens will be transferred to the SMARC and housed in custom made aquatic holding systems. Edwards Aquifer diving beetles are predators; they will be fed small invertebrates (e.g., ostracods).

**PROPAGATION**—Propagation methods for this species are to be determined and will be conducted as part of normal refugia operations.

Texas troglobitic water slater:

**COLLECTION**—Texas troglobitic water slater are primarily found in Artesian Well on Texas State Campus. Recent research by Dr. Will Coleman shows these are deep aquifer species that are rarely found at the surface. Dr. Coleman was unable to keep any alive for extended periods of time, as all specimens he collected came out of the spring damaged. We will continue to work with invertebrate experts in the field to determine what might be the optimum way to collect this species. Drift nets will be deployed and checked by USFWS staff when we are able to sample Texas State University Artesian Well (when not in use by Texas State staff).

**MAINTENANCE**—Captured specimens will be transferred to the SMARC and housed in custom made aquatic holding systems. Initially the species will be fed detrital matter and matured biofilms colonized on cotton lures. The species is also fed fish flake food to supplement their diet.

**PROPAGATION**—Propagation methods for this species are to be determined and will be conducted as part of normal refugia operations.
Table 3. A tentative schedule for all species sampling during 2020. Collections listed here are subject to change with extenuating circumstances such as weather and coordination with external partners. EEA and partners will be notified of sampling dates as they become known or changed.

<table>
<thead>
<tr>
<th>Date (month)</th>
<th>Interval</th>
<th>Location</th>
<th>Target Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>Check 2 consecutive weeks</td>
<td>Rattlesnake Cave &amp; Rattlesnake Well</td>
<td>Texas blind salamander</td>
</tr>
<tr>
<td>January</td>
<td>Collect lures</td>
<td>Spring Runs, Landa Lake</td>
<td>CSRB, CSDB, PCA, TTWS</td>
</tr>
<tr>
<td>January</td>
<td>1 day sampling event, hand pick from downed wood</td>
<td>Landa Lake</td>
<td>CSDB</td>
</tr>
<tr>
<td>January</td>
<td>1 day sampling event, hand pick</td>
<td>Landa Lake</td>
<td>Peck’s Cave amphipod, UNFH</td>
</tr>
<tr>
<td>February</td>
<td>Check for 2 consecutive weeks</td>
<td>Primer’s Fissure &amp; Johnson’s Well</td>
<td>Texas blind salamander</td>
</tr>
<tr>
<td>February</td>
<td>1 day sampling event</td>
<td>San Marcos River</td>
<td>Texas wild rice</td>
</tr>
<tr>
<td>February</td>
<td>1 day sampling event, hand pick</td>
<td>Landa Lake</td>
<td>Peck’s Cave amphipod, UNFH</td>
</tr>
<tr>
<td>March</td>
<td>Check nets T and F every week</td>
<td>Diversion Springs</td>
<td>Texas Blind salamander, San Marcos salamander</td>
</tr>
<tr>
<td>March</td>
<td>1-2 day sampling event</td>
<td>Spring Lake and below dam</td>
<td>San Marcos salamander</td>
</tr>
<tr>
<td>March</td>
<td>1 day sampling event, hand pick</td>
<td>Landa Lake</td>
<td>Peck’s Cave amphipod, UNFH &amp; SMARC</td>
</tr>
<tr>
<td>March</td>
<td>1 day sampling event</td>
<td>Comal Springs</td>
<td>Comal Springs salamander</td>
</tr>
<tr>
<td>Date (month)</td>
<td>Interval</td>
<td>Location</td>
<td>Target Species</td>
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<tr>
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</tr>
<tr>
<td>March</td>
<td>1 day sampling event, hand pick from downed wood</td>
<td>Landa Lake</td>
<td>CSDB</td>
</tr>
<tr>
<td>April</td>
<td>Check 2 consecutive weeks</td>
<td>Rattlesnake Cave &amp; Rattlesnake Well</td>
<td>Texas blind salamander</td>
</tr>
<tr>
<td>April</td>
<td>1-day sampling event</td>
<td>San Marcos River</td>
<td>Texas wild rice</td>
</tr>
<tr>
<td>April</td>
<td>Throughout, coincide with bio-monitoring</td>
<td>San Marcos River</td>
<td>Fountain darters</td>
</tr>
<tr>
<td>April</td>
<td>Set lures</td>
<td>Spring Runs, Landa Lake</td>
<td>CSRB, CSDB, PCA, TTWS</td>
</tr>
<tr>
<td>May</td>
<td>Check 2 consecutive weeks</td>
<td>Primer's Fissure &amp; Johnson's Well</td>
<td>Texas blind salamander</td>
</tr>
<tr>
<td>May</td>
<td>1-day sampling event</td>
<td>San Marcos River</td>
<td>Texas wild rice</td>
</tr>
<tr>
<td>May</td>
<td>Check lures</td>
<td>Spring Runs, Landa Lake</td>
<td>CSRB, CSDB, PCA, TTWS</td>
</tr>
<tr>
<td>June</td>
<td>Check nets T and F every week</td>
<td>Diversion Springs</td>
<td>Texas Blind salamander, San Marcos salamander</td>
</tr>
<tr>
<td>June</td>
<td>1 day sampling event, hand pick</td>
<td>Landa Lake</td>
<td>Peck’s Cave amphipod, SMARC</td>
</tr>
<tr>
<td>June</td>
<td>1 day sampling event</td>
<td>Comal Springs</td>
<td>Comal Springs salamander</td>
</tr>
<tr>
<td>June</td>
<td>Set lures</td>
<td>Western Shore</td>
<td>CSRB, CSDB, PCA, TTWS</td>
</tr>
<tr>
<td>Date (month)</td>
<td>Interval</td>
<td>Location</td>
<td>Target Species</td>
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<tr>
<td>July</td>
<td>Check for 2 consecutive weeks</td>
<td>Rattlesnake Cave &amp; Rattlesnake Well</td>
<td>Texas blind salamander</td>
</tr>
<tr>
<td>July</td>
<td>Check lures</td>
<td>Western Shore</td>
<td>CSRB, CSDB, PCA, TTWS</td>
</tr>
<tr>
<td>August</td>
<td>Check for 2 consecutive weeks</td>
<td>Primer's Fissure &amp; Johnson's Well</td>
<td>Texas blind salamander</td>
</tr>
<tr>
<td>September</td>
<td>Check nets T and F every week</td>
<td>Diversion Springs</td>
<td>Texas Blind salamander, San Marcos salamander</td>
</tr>
<tr>
<td>September</td>
<td>1-2 day sampling event</td>
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</tr>
<tr>
<td>September</td>
<td>1 day sampling event</td>
<td>Comal Springs</td>
<td>Comal Springs salamander</td>
</tr>
<tr>
<td>October</td>
<td>Check every T &amp; F for 2 consecutive weeks</td>
<td>Rattlesnake Cave &amp; Rattlesnake Well</td>
<td>Texas blind salamander</td>
</tr>
<tr>
<td>October</td>
<td>Throughout, coincide with bio-monitoring</td>
<td>San Marcos River</td>
<td>Fountain darters</td>
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</tr>
<tr>
<td>November</td>
<td>Check every T &amp; F for 2 consecutive weeks</td>
<td>Primer's Fissure &amp; Johnson's Well</td>
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<tr>
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</tr>
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<td>Check nets T and F every week</td>
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<td>Texas Blind salamander, San Marcos salamander</td>
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<td>1 day sampling event, hand pick</td>
<td>Landa Lake</td>
<td>Peck’s Cave amphipod, SMARC</td>
</tr>
</tbody>
</table>

**Refugium Stocks:**

**COLLECTION**—Standing Stock numbers contribute to Refugium Stock numbers and collections will continue until Standing stock numbers are attained. In the event that Refugium Stock triggers, outlined in the contract, are reached and Standing Stock are not at full capacity, special targeted collections will be conducted to build up numbers.

**MAINTENANCE**—Maintenance will be conducted in a similar manner described for standing stocks.

**PROPAGATION**—Propagation for stocking is not anticipated during 2020.

**Salvage Stocks:**

**COLLECTION**—If species-specific salvage triggers defined in the EAHCP are reached, the Refugia Program, in consultation with the EAA, will accommodate salvaged organisms no more than two times during the 12-year period. If triggers for multiple species are simultaneously reached, species collections during salvage operations will be prioritized.
based upon the perceived species-specific effect of reduced river and spring flow and habitat
degradation (i.e. EAHCP triggers). Those species that are river obligate species (i.e., fountain
darter and Texas wild-rice) or that occupy spring orifice and interstitial ground water habitats
(i.e., San Marcos and Comal Springs salamander, Peck's Cave amphipod, Comal Springs
dryopid beetle) are presumed to be affected first as flows decrease. Those that reside solely
within the aquifer (i.e., Edwards Aquifer diving beetle, Texas troglobitic water slater and
Texas blind salamander) are presumed to be affected subsequently.

**MAINTENANCE**—Organisms collected during salvage operations would be maintained at the
SMARC for a limited duration (up to one-year) or until their disposition is determined. Research
may be suspended or terminated if space is required for salvaged organisms. Research may also
be suspended if personnel are directed to collection and maintain salvage stocks.

**PROPAGATION**—Likewise, production of species would be limited to no more than two times
during the 12-year period once species extirpation is determined. Species produced at the SMARC
would be held for a limited time (up to one year) or less if stocking is required. Research activities
may be suspended or terminated if space is required to house cultured species. Research may also
be suspended if personnel are directed to reproduce, maintain, or stock salvage stocks or standing
stock progeny.

**Construction/Renovation/Infrastructure/Facility**: The SMARC Center Director will develop and
maintain a list of warranty problems during the 1-year warranty period, forwarding items, as they
occur, to the Contracting Officer (CO) and the USFWS Project Manager (COR).

All reasonable and practical security measures will be instituted by SMARC and UNFH staff to
safeguard EAA refugia facilities, equipment, and species.

**Staffing/Labor/Personnel**: The Supervisory Fish Biologists (SFBs) at both the SMARC and UNFH
will continue in their duties including, but not limited to: supervising, mentoring, and training
lower-graded employees, authorize purchases, oversee facility maintenance and repair, develop
and implement budgets, and organize activities that relate to all contract activities. The SFBs will
manage, and coordinate research, propagation, culture, and field activities related to the refugia.
The SFBs are expected to provide proper and efficient use of facilities and staff resources. The
SFBs will work with the Center Director to ensure that contractual obligations are met in a timely
manner. In coordination with the Center Director, they will prepare all the required written
materials required for the reimbursable agreement reporting. Likewise, the SFBs will also prepare
oral presentations to be used as briefing statements, outreach presentations, internal reports, work
summaries, and technical presentations at professional meetings. The two SFBs will continue to
work and communicate regularly with partners, Service personnel and other researchers to
effectively meet Service and reimbursable agreement goals.

Under the management of a lead supervisory biologist at both facilities, it is expected that six
Biological Science Technicians, three at each station, will continue to assist with the collection,
daily upkeep, maintenance, propagation, and research efforts for the ten species at the SMARC
and UNFH. This includes maintaining experimental and culture production systems, keeping
records along with entering, filing, and collating data. The technicians will also generate basic summary statistics and graphic analyses of data and document program accomplishments through the composition of Standard Operating Procedures (SOPs), reports, and manuscripts. We will advertise for an additional animal care-taker position located at SMARC to help with day to day activities as Biological Science Technicians and the Supervisory Fish Biologist have additional collections and are involved in many of the refugia research projects.

PERMITTING: Both the UNFH and SMARC operate under the USFWS Southwest Region’s Federal Fish and Wildlife Permit for Native, Endangered, and Threatened Species Recovery (number TE676811-3) and the Texas Parks and Wildlife Scientific Research Permits (UNFH SPR-1015-222, SMARC SPR-0616-153).


Target for 2020 Task 2. Research: The Research Plan for 2020 will involve a series of activities ranging from increasing survival rates of various invertebrate species, virus transfer in darter, to reproduction of Texas blind salamanders. The following section describes the basic components of each of these proposed 2020 activities.

Project 1:
**Title:** Increasing survival rates of Peck’s cave amphipod adults and F1 offspring  
**Species:** *Stygobromus pecki*  
**Principal/Co-PI:** Amelia Hunter, Makayla Blake, Dr. Lindsay Campbell  
**Overview:** Different habitat enrichment items will be tried in holding containers for Peck’s cave amphipods (PCA) to increase survival rates for wild stock adults. In addition, different food items will be added to test containers such as frozen tubifex worms or pellet foods, to see if they are a viable addition or alternative to fish flake that is currently given. Prototype holding containers for brooding females will be tested against the current brooding chambers employed for increased survival rates of F1 offspring.  
**Budget:** $49,000  
**Benefit to the Refugia:** Increased survival rates of PCA and continued refinement of propagation techniques.  
**Expected Results:** The results of the study will be presented as a report to the EAA and if warranted an update to the PCA standard protocols.

Project 2:  
**Title:** Continuation of increasing survival rates of Comal Springs dryopid beetle in captivity  
**Species:** *Stygoparnus comalensis*  
**Principal/Co-PI:** Dr. Ely Kosnicki, Bio-West, Inc
Overview: Different holding containers and habitat enrichment items will be evaluated for housing dryopid beetles and reducing the movement between containers of beetle eggs and larvae. Designs will also be tested in their ability to house larger numbers of beetles.

Budget: $40,000

Benefit to the Refugia: Increases survival rates of wild stock Comal Springs dryopid beetles in captivity and increased efficiency in F1 production.

Expected Results: The results of the study will be presented as a report to the EAA and if warranted an update to the Comal Springs dryopid beetle standard protocols.

Project 3:

**Title:** Continuation of San Marcos salamander reproduction

**Species:** Eurycea nana

**Principal:** Kelsey Anderson, Rachel Wirick, Dr. Lindsay Campbell

Overview: We plan to follow up on the information learned during 2019 on San Marcos salamander pathology reports by sourcing alternative foods that are not high in barium. We will investigate measures to reduce the number of free microsporidia spores in tank water. We will also consult an outside salamander reproductive specialist on potential changes to reproductive practices and use of amphibian hormones to induce mating.

Budget: $65,000

Benefit to the Refugia: Continued refinement of salamander reproduction and propagation. Information gained will inform reintroduction strategy.

Expected Results: The results of the study will be presented as a report to the EAA, an update to the reintroduction strategy, and update to the Eurycea sp. Propagation Manual.

Project 4:

**Title:** Continuation of Comal Springs riffle beetle nutrition and survivorship research

**Species:** Heterelmis comalensis

**Principal:** Amelia Hunter, Linda Moon, Dr. Lindsay Campbell, Dr. Camila Carlos-Shanely

Overview: We plan to continue research into nutrition supplementation to increase survival rates. We will conduct a food preference test of artificial diets. We will use a food-grade 3D printer to construct matrices for biofilm growth as compared to cotton cloth. Research into the identification of the specific microbiome from Comal Springs riffle beetle gut content analysis will continue to compare wild microbiomes to those of captive microbiomes. Based on preliminary results, we will conduct a trial using cultured Chromobacterium sp. to determine if there are negative effects on larvae due to its presence in culture systems.

Budget: $100,000

Benefit to the Refugia: Increased survival rates of Comal Springs riffle beetles.

Expected Results: Interim reports to USFWS and EAA on the successes and failures of various techniques tried and knowledge gained.
**Project 5:**

**Title:** Continuation of increasing pupation success in the Comal Springs riffle beetle in a captive setting

**Species:** *Stygoparnus comalensis*

**Principal/Co-PI:** BIO-WEST, Inc., input by SMARC staff

**Overview:** The purpose of this project is to identify conditions that are optimum for incurring successful pupation and eclosion for Comal Springs riffle beetles. Increased replicates of the most effective designs of holding larvae in flow-through tubes will be implemented. These designs will also be tested on larvae collected from the wild.

**Budget:** $75,000

**Benefit to the Refugia:** A better understanding of factors influencing pupation will allow for increased offspring production in captivity, better estimation of production in captivity, more efficient husbandry practices, and better knowledge to create a reintroduction strategy for this species.

**Expected Results:** A report on the successes and failures of methodologies tested to increase pupation rates.

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**Project 6:**

**Title:** Continuation of examination of the life history of the Comal Springs riffle beetle (*Heterelmis comalensis*) and assessment of factors which affect pupation rates

**Species:** *Stygoparnus comalensis*

**Principal/Co-PI:** Dr. Weston Nowlin, Texas State University, input by SMARC staff

**Overview:** Examine several factors which may contribute to successful pupation and emergence of adult Comal Springs riffle beetles in a captive setting. Specifically, examining three factors in captivity: 1) How does the origin (wild or lab-grown biofilms) and nutritional and microbial composition of biofilms utilized by riffle beetle larvae affect pupation and adult eclosion rate in captivity?; 2) Does the presence of conspecifics (Comal Springs riffle beetles) affect the quality (i.e., microbial composition and nutritional value) of biofilms utilized by Comal Springs riffle beetle larvae prior to pupation?; and 3) How does the concentration of DO affect the survival and development of Comal Springs riffle beetle pupae and emergence of adult beetles in the lab? Increased replications of the most effective factors will be tested as well as tested on larvae collected from the wild.

**Budget:** $75,000

**Benefit to the Refugia:** A better understanding of factors influencing pupation will allow for increased offspring production in captivity, better estimation of production in captivity, more efficient husbandry practices, and better knowledge to create a reintroduction strategy for this species.

**Expected Results:** A report on the successes and failures of methodologies tested to increase pupation rates.

---

**Project 7:**
Title: Continuation of evaluating three different long-term tagging methods in aquatic salamander species

Species: *Eurycea nana, Eurycea rathbuni, Eurycea sp.8*

Principal: Dr. Lindsay Campbell, Linda Moon

Overview: The objective of the proposed study is to determine the efficacy of various tagging methodologies to best visually mark covered salamanders species for quick identification of captively held salamanders.

Budget: $30,000

Objectives and Methods: We will finish out a full year of evaluating the three different tag methods: Visible Implant Elastomer tags, Visual Implant Alphanumeric tags, and small Passive Integrated Transponders. Tags and injection sites will be monitored overtime for health, retention, and clarity/readability.

Expected Results: The results of the study will be presented as a report to the EAA and submitted to a peer reviewed journal. A presentation of the project will be given at a national conference. If a marking technique(s) is/are successful the Captive Propagation Manual for this species will be updated to include how marking can be effectively used in husbandry practices.

Target for 2020 Task 3. Species Propagation and Husbandry:
*Development and refinement of SOPs for animal rearing and captive propagation:* Continue to refine SOPs for all species as needed for updates to reflect new protocols that are instituted for each species throughout the year. As new information becomes available about genetic management, further develop draft Captive Propagation Plans for all species.

Target for 2020 Task 4. Species Reintroduction:
*Reintroduction Plan for term of contract:* Continue to refine the Reintroduction Strategy as new information becomes available.

*Reintroduction Plan for 2020:* None

*Any anticipated triggers being prepared for:* Given current weather predictions, spring flows, and the Edwards Aquifer water level none are anticipated during the 2020 performance period.

Target for 2020 Task 5. Reporting:
*Species specific Propagation plans (SOPs):* Refine throughout year as needed.

*Species specific Genetic Management plans:* None during 2020.

*Species specific Reintroduction plans:* Refine as needed.
2020 EAHCP Annual Program reporting: USFWS will provide a year-end report of 2020 activities to the EAA no later than 1/31/2021.

Program reporting as required by ITP and TPWD: TPWD Scientific Research Permit Report will be conveyed to the EAA July 31, 2020.

Descriptions and photographs of procedures from collections to restocking: Photographs and documentation of collection and restocking will be included in the monthly report to the EAA CSO along with the year-end report.

Summaries of any data analyses, research, or genetic analyses: Research projects and results of collection efforts will be provided to the EAA in the monthly reports, year-end documentation, and stand-alone documents (agreed upon by the Center director and EAHCP CSO).

Description of terms and conditions of any permits received: As permits are received, their contents will be conveyed to the EAA.

Monthly electronic reports to EAHCP CSO: A monthly report of all activities will be provided to the EAHCP CSO. USFWS anticipates providing the report by the 10th of each month for the previous month’s activities.

Target for 2020 Task 6. Meetings and Presentations:

- Planning or coordination meetings:
  - Yearly planning meeting with SMARC and UNFH staff

- Public meetings
  - EAA Board
    - End of year report
    - Present research results
  - Implementing Committee
    - End of year summary
  - Stakeholder Committee
    - End of year summary
  - Science Committee
    - Methods for research projects
    - Present research results

Monitoring:
Monitoring will be conducted through the use of progress reports and site visits to the refugia as well as through collaborative management by the EAHCP CSO.
## Budget: Projected 2020 budget

### U.S. Fish and Wildlife Service 2020

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<th>Task</th>
<th>Task Budget Amount</th>
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Subtotal: $13,368.38

Admin costs for Task 6: $2,272.62

TOTAL: $1,151,657.30

Total Projected (2020) Budget Summarized by Task:
- Task 1: $612,538
- Task 2: $444,176
- Task 3: $0
- Task 4: $0
- Task 5: $79,303
- Task 6: $15,641

Projected (2020) Subcontractor Expenses Summarized by Task:
- Task 1: Southwest Regional Fish Health Unit, Dexter, NM $8,000 (Health Diagnostics)
- Task 2: BIO-WEST, Inc, $115,000; Texas State University, Dr. Weston Nowlin, $75,000; Washington Animal Disease Diagnostic Laboratory $10,000; Dr. Ruth Marcee-Greaves, $2,500; Dr. Camila Carlos-Shanley’s Laboratory $25,000
- Task 3: $0
- Task 4: $0
- Task 5: $0
- Task 6: $0

2020 available budget: $1,151,682

Estimated 2020 budget: $1,151,682
Timeline of 2020 Milestones
(List major deliverables)

January  
- Continue with species collection
- Subcontract research awards executed
- 2020 Specific Research Study Plans finalized

July
- Submit and renew TPWD permit

September to
- Draft Research Reports

December
- Draft Annual Report

Literature Cited


FMA § 2.2 EAHCP Program Management

Section 2.2 of the Funding and Management Agreement (FMA) assigns “general management and oversight” of the Edwards Aquifer Habitat Conservation Plan (EAHCP) to the Edwards Aquifer Authority (EAA). Section 5.6.5 of the FMA allows the EAA to use EAHCP funds for administrative costs and employee salaries, so long as all incurred costs and salaries are 100% related to “general management and oversight” of the EAHCP.

Long-term Objectives:
To manage and oversee day-to-day operations and administration, in coordination with the Applicants, of the EAHCP; resulting in a valid and continued Incidental Take Permit (ITP) from the U.S. Fish and Wildlife Service (USFWS) for designated Covered Activities. Additionally, to prepare for, gather information to be used in, and implement the Strategic Adaptive Management decision-making process.

Program Management: In 2020, EAHCP staff will continue to coordinate and monitor the work outlined in the Conservation Measures consistent with the Phase II Work Plan including the Biological Monitoring, Water Quality Monitoring, ASR, and VISPO described in this work plan. The Chief Science Officer and Environmental Scientist will oversee the continued development and operations of the Refugia Program which will also include all Refugia research activities. In 2020, the EAHCP staff will also continue to update the EAHCP biological and water quality monitoring databases.

EAHCP staff will also continue the following activities in 2020:

Program Manager: The EAHCP Program Manager will execute duties as assigned in the FMA and:
- Serve on the ASR Advisory Committee,
- Facilitate the Adaptive Management Process (AMP) for all Routine, Nonroutine and Strategic AMP decisions,
- Facilitate and coordinate all meetings of the EAHCP Implementing, Science and Stakeholder committees and possible Subcommittees and Work Groups as created by the Implementing, Science and Stakeholder committees.

EAHCP Staff: The EAHCP staff will continue the following activities:
- Prepare for all meetings of the EAHCP Implementing, Science, and Stakeholder committees, (and possible Subcommittees and Work Groups as created by the Implementing, Science and Stakeholder committees);
- Prepare materials for all AMP activities;
- Procure and execute contracts;
- Oversee contract tracking and compliance;
- Process and pay all contractor’s invoices;
- Oversee the City of New Braunfels and San Marcos/Texas State University work plan activities;
- Coordinate 2020 Work Plan amendments and the development of 2021 Work Plans and Funding Applications;
Draft and submit to the USFWS the informational memorandums, clarifications, and amendments to the ITP and EAHCP;
Participate in public outreach initiatives;
Publish the EAHCP Steward newsletter;
Enhance the EAHCP.org website;
Prepare and compile all Permittees’ information for the annual report to USFWS; and
Track and assist EAHCP Permittees with maintaining compliance with secondary implementation permits, such as: U.S. Army Corps of Engineers, Texas Parks and Wildlife Department, Texas Commission on Environmental Quality, General Land Office, and Texas Historical Commission permits.

Adaptive Management Process (AMP): EAHCP staff, under direction of the Program Manager, will manage the AMP as defined in the FMA. Specifically, Article 7 defines the procedures for the AMP. EAHCP staff will also serve as a liaison to USFWS in the AMP.

EAHCP Implementing, Science and Stakeholder committees and Work Groups and Subcommittees: EAHCP staff, under the direction of the Program Manager, will continue to manage the meetings and activities of all EAHCP Committees and any Subcommittees or Work Groups. The Implementing and Science committees will meet according to approved schedules and the Stakeholder Committee will meet quarterly unless otherwise convened for the AMP.

Staffing in 2020:
The EAHCP staff consists of the Program Manager, EAHCP Manager, Contract Administrator, and two EAHCP Coordinators. EAA funds the Chief Science Officer and the Environmental Scientist staff positions. Two positions remained vacant during the development of this work plan, but both could be filled in 2020. The structure of the existing EAHCP staff positions and EAA-funded positions – the Threatened and Endangered Species Team - are illustrated in the chart on the next page.
Threatened and Endangered Species Team

- EAHCP Program Manager/ Senior Director
  - EAHCP Manager
  - Administrative Assistant
  - Chief Science Officer
    - Environmental Scientist
    - Senior Program Coordinator
  - Habitats Conservation Coordinator
  - Contract Administrator
  - Habitats Conservation Coordinator

Legend:
- Positions Paid from EAA General Budget
- Vacant Positions
Budget:
The following table summarizes the estimated EAHCP Program Management budget for 2020.

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2020 available budget: $750,000

Estimated 2020 budget: $1,033,435
City of San Marcos/Texas State University 2020
Work Plan
## 2020 San Marcos/Texas State University Work Plan Budget

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<td>$30,000</td>
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<td>5.3.4</td>
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<td>$0</td>
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<td>$0</td>
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<tr>
<td>5.7.3,4,5,7,8,9 &amp; 10</td>
<td>Various unfunded Measures</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
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<td><strong>Total</strong></td>
<td><strong>$616,000</strong></td>
<td><strong>$596,000</strong></td>
<td><strong>$571,000</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Will add construction costs when bid is tabulated. Construction is anticipated from 2021-2023.

**Sediment Management funding will go towards the Impervious Cover and Water Quality Protection Conservation Measure (5.7.6) per the 2017 Sediment Removal and Impervious Cover/Water Quality Protection nonroutine adaptive management
5.3.1/5.4.1 Texas Wild-Rice Enhancement and Restoration

Long-term Objective:
To achieve 8,000 – 15,450 m² of Texas wild-rice (TWR) and maintain existing and restored areas of TWR as required by the EAHCP.

Target for 2020:
The target area for planting TWR in 2020 is Spring Lake. The primary focus area within Spring Lake that has been identified for new plantings is the area above the eastern spillway. The entire lake, except for the area adjacent to the Meadows Center for Water and the Environment headquarters, is also targeted for planting of TWR in areas of hygrophila removal. The remainder of the TWR, from Spring Lake Dam to IH-35, will be encouraged to expand through invasive removal within and around the perimeter of TWR stands, or planted if needed. These efforts work toward attaining 2027 biological goals as shown in Table 1.

Table 1. TWR expansion since 2013 relative to 2027 biological goals

<table>
<thead>
<tr>
<th>Reach</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2027 Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring Lake</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>47</td>
<td>184</td>
<td>246</td>
<td>1000</td>
</tr>
<tr>
<td>Spring Lake Dam</td>
<td>199</td>
<td>360</td>
<td>573</td>
<td>887</td>
<td>1389</td>
<td>1088</td>
<td>700</td>
</tr>
<tr>
<td>Sewell Park</td>
<td>666</td>
<td>839</td>
<td>1202</td>
<td>1186</td>
<td>1811</td>
<td>1191</td>
<td>1100</td>
</tr>
<tr>
<td>Below Sewell-City Park</td>
<td>1212</td>
<td>1963</td>
<td>2253</td>
<td>2429</td>
<td>2810</td>
<td>2726</td>
<td>2300</td>
</tr>
<tr>
<td>City Park</td>
<td>384</td>
<td>603</td>
<td>1348</td>
<td>1562</td>
<td>2247</td>
<td>1361</td>
<td>1750</td>
</tr>
<tr>
<td>Hopkins St-Snake Island</td>
<td>0</td>
<td>0</td>
<td>693</td>
<td>0</td>
<td>1169</td>
<td>815</td>
<td>950</td>
</tr>
<tr>
<td>Cypress Island-Rio Vista</td>
<td>0</td>
<td>0</td>
<td>123</td>
<td>238</td>
<td>247</td>
<td>249</td>
<td>350</td>
</tr>
<tr>
<td>IH-35 (Upper &amp; Lower)</td>
<td>0</td>
<td>0</td>
<td>82</td>
<td>276</td>
<td>512</td>
<td>621</td>
<td>1050</td>
</tr>
<tr>
<td>Below IH-35</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>56</td>
<td>76</td>
<td>280</td>
</tr>
</tbody>
</table>

Methodology: The optimal conditions for TWR are sandy to coarse soils with water depths generally greater than 1 meter in areas of higher current velocity. In stands of TWR that have non-native plant species intermixed, the non-natives are removed and the original TWR stand is monitored for expansion. Similarly, for TWR stands adjacent to non-native vegetation; the non-native plants in the San Marcos River are removed and TWR is planted. Finally, in sites that are potentially suitable for TWR but are unoccupied by TWR in Spring Lake and downstream of IH-35, any non-native vegetation that is present is removed and TWR planted and monitored to assess the success of transplants.

Removal of invasive non-natives around existing TWR stands occurs by hand, with divers allowing the non-native plants to drift into a seine, bag, or catch net set up downstream. The removed vegetation is moved to the shore and plant debris is transferred to the work truck or trailer. There, the plants are shaken to remove trapped fauna which are returned to the river. The plants are then disposed at the COSM or Spring Lake composting facility. Denuded areas are monitored and any regrowth of non-native plants is removed. If TWR does not expand, other native aquatic plants will be planted to secure the area.
The contractor will grow TWR from both tillers and seeds with mature seeds being collected from the panicle by gently pulling upwards until seeds are released. Mature seeds are plump, filled out, and either green or brown in color. Seeds are then placed in a plastic bag during collection and counted and potted within 24 hours following collection. Tillers of TWR are collected by removing them from floating vegetation mats or from fragments attached to mature plants in the river. TWR tillers are transported to the raceways located at the Freeman Aquatic Biology (FAB) and potted in soil that consists of a bulk mixture containing top soil and mushroom compost. TWR tillers are planted in an 8-inch pot with the soil being highly saturated with water so that the tillers can be inserted without causing damage to the plant. Density of fragments per pot is generally 3-10 individuals depending on the species. TWR seeds are placed on top of inundated soil in 8-inch pots and covered with pea gravel to secure the seeds from floating in the water. Seeds are spread out evenly within each pot, and gently pushed into the saturated soil and gravel mixture. Once TWR seeds have germinated they will be separated out and planted in a similar manner as TWR tillers.

The pots are placed into the FAB raceways with pumps generating current velocity over the newly planted fragments. Plants remain in the raceways until roots are firmly established in the pots.

The process of planting in the river begins by transporting potted TWR individuals from the FAB to the planting site. A diver and a handler carry the plants to the designated section, and while the diver digs a hole in the substrate using a trowel, the handler gives the diver a pot of TWR. The contents are removed from the pot and inserted into the hole. The diver works downstream to upstream in a linear pattern of planting. Individuals are placed about 0.5 meters apart and gardened as needed to remove invading plants. This process is adjusted as needed to meet the varying conditions of each planting site and species.

Production of TWR plants at the FAB is incorporated into this Work Plan budget (TWR Enhancement & Removal of non-natives). These methodologies may be adjusted as more is learned about collection and planting procedures.

Monitoring:
All planted areas are monitored via quadcopter and scuba divers. This data is mapped and analyzed via GIS. Monitoring thus far has shown that invasive plants move into cleared areas more quickly than TWR, so cleared areas are now planted with either TWR or an approved native plant (see conservation measure 5.3.8/5.4.3/5.4.12 Control of Non-Native Plant Species). TWR distribution is also monitored annually through the EAA BioMonitoring program. The data collected is used to evaluate TWR coverage and identify areas of concern.

Budget:
Table 7.1:
$100,000
Available budget for 2020
Estimated 2020 budget:

$73,750*

*Transferring $26,250 to Control of Non-native Plant Species
5.3.6/5.4.4 Sediment Management

The City of San Marcos (COSM) and Texas State University (TXSTATE) are partnering to remove sediment from the river bottom in support of the native SAV planting program from Spring Lake to IH-35.

Long-term Objective:

The removal of sediment in support of native aquatic planting activities has proven to be both ineffective and expensive. From 2013 to 2015, three of the six required sites have received only 158 m³ of sediment removal costing approximately $555,000. In 2017, an Adaptive Management Proposal to amend this conservation measure in the EAHCP was approved.

The Sediment Removal and Impervious Cover/Water Quality Protection are combined into one conservation measure that addresses sediment control within the upper San Marcos River watershed to minimize sediment and other contaminated runoff. The primary focus is the Sessom Creek watershed, which contributes a heavy load of sediment during rain events; in the 2015 October flood, Sessom Creek dumped sediment on TWR stands and other native plant stands down to City Park.

The COSM will provide; (1) design of wastewater relocation and erosion/sediment control in Sessom Creek; (2) Sessom wastewater line rehab and relocation; and (3) construction of stormwater control (SWC) features and associated land management tasks that control erosion, minimize sedimentation, and reduce pollutants in the Sessom Creek watershed.

Additionally, TXSTATE has received 319 funding from the TCEQ for SWCs in the Sessom Creek watershed. The Meadows Center for Water and the Environment is the point of contact for the EPA 319 funds.

Target for 2020:

See discussion in Section 5.7.6 Impervious Cover/Water Quality Protection

Method:

See discussion in Section 5.7.6 Impervious Cover/Water Quality Protection

Budget:

Table 7.1:

|$25,000

Available budget for 2020:

|$25,000*

Estimated budget for 2020:

|$0

*These funds will be transferred to the Impervious Cover and Water Quality Protection measures.
5.3.8/5.4.3/5.4.12 Control of Non-Native Plant Species

Long-term Objective:
To decrease the density of invasive aquatic and littoral plants or eliminate as possible through monitored removal in and along the San Marcos River and to enhance fountain darter habitat by increasing the distribution of native aquatic flora as assigned by the submerged aquatic vegetation (SAV) nonroutine adaptive management long-term goals.

Target for 2020:
In 2020, the removal of non-natives and planting of natives will adopt the following strategy in an effort to ensure best use of EAHCP funds and facilitate the achievement of long-term biological goals.

Hygrophila will be removed from various sites within Spring Lake (Figure 1). In Spring Lake, volunteers will be used to remove non-natives and plant non-TWR natives because at this time the EAHCP only covers planting of TWR in Spring Lake. TWR plantings have not been successful in areas of high silt. This reach will receive repeated removal treatments until non-native regrowth is slow enough to allow natives to outcompete them. Figure 2 represents the 2020 work zone for removal of non-natives. The 2019 work zones will be classified as recovery zones in 2020 (Figure 3). These recovery zones will be managed so that native species can expand either naturally or via planting while maintenance zones will be regularly swept for remnant hydrilla plants (Figure 4). The contractors will continue utilizing extended hours from May to October to take advantage of the extended periods of daylight and to avoid hours of heavy river recreation.
Figure 1. Proposed work zone for non-native removal and TWR planting in 2020.

Figure 2. Proposed work zone for non-native removal and native aquatic planting in 2020.
Figure 3. Proposed 2020 recovery zones and areas of focused recovery effort.

Figure 4. Proposed 2020 maintenance zones.
Methodology:

Non-Native Aquatic Plant Removal

Work efforts will focus on replacing 20 – 50% of removed non-native species within a given reach with natives, focusing on species diversity, species habitat preferences, and available habitat at the time of planting. The goal will be to eliminate dense stands of non-native species that then allow the native species to maintain and/or expand their distribution. The mean number of fountain darters per square meter will be an important factor when replacing the non-native species with native species so total fountain darter numbers are not reduced following removal and planting efforts.

Non-native aquatic plants will be removed and replaced with native aquatic plants in association with TWR enhancement as described in conservation measure 5.3.1/5.4.1. Divers remove non-native aquatic plants by hand, allowing them to drift into a seine, bag, or catch net set up downstream. The removed vegetation is moved to the shore and plant debris is transferred to the work truck or trailer. There, the plants are shaken to remove trapped fauna which are returned to the river. The plants are then disposed at the COSM or Spring Lake composting facility. Denuded areas are left alone for several weeks and any regrowth of non-native plants is removed, then the area is planted with native aquatic vegetation.

Hydrilla Removal

The upper San Marcos River was separated into eleven reaches from Spring Lake to Stokes Park. Hydrilla has been removed from seven of these reaches since 2013 with limited success. Hydrilla was removed from these reaches regardless of reach location along the upper river, which left large areas of untouched hydrilla upstream of removed areas that resulted in the cleared areas being quickly repopulated with large stands of this invasive species. Beginning in 2018, HCP contractors began a systematic upstream to downstream removal strategy beginning in the Spring Lake Dam reach. Currently there is very little hydrilla within Spring Lake and it is managed to a level that the lake should not be an upstream source of hydrilla fragments or tubers.

Hydrilla is now being systematically removed reach by reach. Reaches that have been thoroughly cleared of large hydrilla patches for two or more years are considered maintenance zones while reaches in which large amounts of hydrilla are being removed are designated as work zones. A work zone in which all hydrilla has been thoroughly removed during the previous year are considered a recovery zone. These recovery zones may still require additional effort to ensure the thorough removal of hydrilla root systems and tubers, which can remain viable for multiple years despite being buried over 12 inches beneath the sediment. Downstream reaches with large areas of hydrilla are considered future work zones. Two reaches are currently considered in maintenance condition and three reaches are currently considered work zones.

Hydrilla is removed by hand and then transported to a trailer for eventual dumping and composting. Areas of removal are then de-rooted, which includes meticulous removal of roots, small plants, and tubers. This process is repeated until no hydrilla is observed. After an area has been effectively de-rooted and no regrowth occurs, native plants are either planted or allowed to populate the cleared areas through natural expansion.
Planting of Native Species

The planting of native species begins once the designation of a work zone changes to recovery zone, as this maximizes reduction of invasive regrowth and subsequent outbreak. This is expected to take 3-6 months from when the site is finished as a work zone, depending on the density and area of non-natives originally present in the site. Efforts primarily focus on preserving areas surrounding existing native species to allow for the natural expansion of those populations throughout the river system. In addition to the use of natural expansion, areas that have been stripped of all vegetation will be planted with native species best suited to that habitat type while ensuring a high level of biodiversity is maintained for that given area. The goal provides species presence within all reaches to allow for natural expansion downstream of each population. An exception to this will include areas within Spring Lake where the Hygrophila will be removed, and replaced by native expansion according to the appropriate substrate, flow, depth, and sunlight.

The practice of removing non-native aquatic plant stands from upstream to downstream is anticipated to reduce labor hours spent on gardening unwanted growth that results from non-native plant fragments drifting from upstream sources, reduce competition for newly planted and existing natives, and allow more time to be spent on planting (as needed). Large homogenous stands of non-native aquatic vegetation will be targeted while mixed stands of native and non-native species will be monitored. Non-native species within mixed stands will be removed if expansion is observed. The plant species designated in Table 2 below will be prioritized for planting after removal of non-native species depending on available habitat and history of the plant species’ success in the available habitat at a given site. If the prioritized species has not been successful in the habitat type to be planted, another species will be planted in its place. Plantings will not occur in areas impacted by intense recreation.

SAV Restoration

In 2018, the SAV and TWR restoration progress in the San Marcos River was evaluated. Based on the results, the species’ coverage estimates were adjusted and Table 2 shows how the coverage estimates compare to the EAHCP biological goals.

Table 2: Current aquatic vegetation coverage relative to the overall restoration goals, in meters squared (m²) within San Marcos LTBG reaches and restoration reaches.
<table>
<thead>
<tr>
<th>Reaches</th>
<th>Species</th>
<th>Coverage(\text{m}^2)</th>
<th>Restoration Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oct 2018</td>
<td>2027</td>
</tr>
<tr>
<td>LTBG Reaches(^1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring Lake Dam</td>
<td>Ludwigia</td>
<td>22.44</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>1.52</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Potamogeton</td>
<td>147.99</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>22.29</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Hydrocotyle</td>
<td>51.08</td>
<td>50</td>
</tr>
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<td>City Park</td>
<td>Ludwigia</td>
<td>65.28</td>
<td>150</td>
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<td></td>
<td>Cabomba</td>
<td>50.1</td>
<td>90</td>
</tr>
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<td></td>
<td>Potamogeton</td>
<td>203.34</td>
<td>1450</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>106.84</td>
<td>300</td>
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<tr>
<td></td>
<td>Hydrocotyle</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>IH-35</td>
<td>Ludwigia</td>
<td>10.12</td>
<td>50</td>
</tr>
<tr>
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<td>Cabomba</td>
<td>31.98</td>
<td>50</td>
</tr>
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<td></td>
<td>Potamogeton</td>
<td>0</td>
<td>150</td>
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<tr>
<td></td>
<td>Sagittaria</td>
<td>17.11</td>
<td>150</td>
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<tr>
<td></td>
<td>Hydrocotyle</td>
<td>3.81</td>
<td>50</td>
</tr>
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<td>Restoration Reaches(^1)</td>
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<td></td>
</tr>
<tr>
<td>Sewell Park</td>
<td>Ludwigia</td>
<td>3.8</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>3.4</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Potamogeton</td>
<td>113.8</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Hydrocotyle</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Below Sewell to City Park</td>
<td>Ludwigia</td>
<td>5.4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>2.2</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Potamogeton</td>
<td>386.1</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>392.4</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>Hydrocotyle</td>
<td>38</td>
<td>20</td>
</tr>
<tr>
<td>Hopkins St to Snake Island</td>
<td>Ludwigia</td>
<td>2.4</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>108.3</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Potamogeton</td>
<td>63.5</td>
<td>475</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>1258.6</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Hydrocotyle</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Cypress Island to Rio Vista Falls</td>
<td>Ludwigia</td>
<td>18.24</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>200.52</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Potamogeton</td>
<td>6.12</td>
<td>150</td>
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<tr>
<td></td>
<td>Sagittaria</td>
<td>14.02</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Hydrocotyle</td>
<td>0</td>
<td>0</td>
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<tr>
<td>IH-35 expanded</td>
<td>Ludwigia</td>
<td>194.11</td>
<td>50</td>
</tr>
</tbody>
</table>

\(^1\) Oct 2018 and 2027 Restoration Goals are based on a 10% increase for the Sewell Park reach, a 20% increase for other City Park reaches, and a 50% increase for IH-35 expanded.
Production of native SAV will continue at the FAB at Texas State University as described in the TWR Enhancement section. Fragments and tillers of native aquatic plants removed from floating vegetation mats or from fragments attached to mature plants in the river are used for propagation at FAB. Funding for the production of SAV at the FAB is incorporated into this Work Plan budget.

Native vegetation species are planted using a team that, at times, includes a diver(s). A hole is made in the substrate using a hand shovel and the native plants are hand planted until the denuded area is approximately 20-70% coverage, depending on species and area planted. The pots are removed before planting and handed back to the assistant for reuse. Planting native plants soon after removal of non-natives is needed to stabilize the substrate.

Environmental conditions at the time of planting determine which native species are planted. *Cabomba* and *Sagittaria* have exhibited greater success in finer substrates (silt) with areas of slower moving water. Both can be planted in a range of water depths. However, some reaches are challenging, such as Cypress Island, where only TWR and *Heteranthera* have shown success in outcompeting *Hydrilla*.

In the San Marcos River, *L. repens* has been planted in a wide variety of habitat types ranging from areas with shallow depths, high velocities over coarse substrates to areas with slackwater habitat over silt substrate to determine which habitat results in greatest rates of expansion and persistence. In 2019, *L. repens* patches have expanded and contracted with fluctuations in recreational areas. This species’ coverage expanded in reaches upstream of Hopkins Street, with many of the new patches being relatively small and occupying areas recently cleared of non-natives. This is possibly occurring, because for the first time, *L. repens* has multiple source populations in the upper San Marcos River. *Hygrophila* has been observed to reduce the expansion of *L. repens*. Their habitat preference seems to be shallow, moderate flow and non-silty substrate, although *L. repens* in City Park is thriving in soft silty substrate.

In 2016, *Hydrocotyle verticillata* was accepted as an approved native species to plant in the San Marcos River. *Hydrocotyle verticillata* can become a littoral species, persisting in areas of

<table>
<thead>
<tr>
<th>Reaches</th>
<th>Species</th>
<th>Coverage (m²)</th>
<th>Restoration Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Cabomba</em></td>
<td>63.52</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>Potamogeton</em></td>
<td>0</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td><em>Sagittaria</em></td>
<td>373.18</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td><em>Hydrocotyle</em></td>
<td>5.47</td>
<td>50</td>
</tr>
</tbody>
</table>

1. 2018 coverage values were mapped in October 2018
shallow water. Therefore, this species is utilized to replant river margins or areas of very shallow water depths.

Non-Native Littoral Plant Removal

Removal of littoral plants and other small caliper invasive plants in the riparian zone is also included in this budget. In 2020, removal efforts for littoral invasives will target areas shown in Figure 5 below. Littoral invasive removal efforts will address seed source and regrowth of invasive plants from above Spring Lake to Stokes Park (Section 5.3.8). Removal of elephant ears may be greater in fall and winter before spring growth. Removal efforts will also extend to treat hot spots that contribute to regrowth. The littoral zone will be replanted as needed to stabilize the bank.

Figure 5. Locations of remaining littoral invasive plant stands.

Re-growth of invasive species will continue to be removed to maintain the desired state. Seed sources will also be targeted.

The herbicide mix used for littoral removal is Aquaneat (glyphosate-based herbicide) for elephant ears and other non-native plants encountered in the littoral zone. This herbicide will be mixed with Aqua King Plus Surfactant and Turf Mark Blue, a blue dye. Chemicals are applied by a licensed applicator with a one-gallon pump-up sprayer set on a steady stream for a more precise target hit to minimize leaching and non-target plant damage. Roots of woody plants are scarred to expose the cambium layer before treated.

Monitoring:

For aquatic plants, newly planted areas are monitored monthly to evaluate success rate. All planting and removal areas are monitored via quadcopter and/or visual observation by snorkelers and scuba divers. Both planting and removal efforts are mapped and quantified via GIS techniques. Work sites are separated into reaches to assess changes among and within reaches of
the San Marcos River and to identify presence of non-native vegetation and also to assess the expansion of native vegetation.

Progress for non-native littoral vegetation removal will be tracked with polygons containing the species removed, estimated area (m²) and percent removed. A composite map depicting the routine maintenance required to remove large areas of non-native aquatic vegetation will also be generated using weekly polygons.

**Budget:**

Table 7.1:

$50,000

Available budget for 2020:

$50,000

Estimated 2020 budget:

$119,277*

*$79,607 TxSt & $42,670 EBR; transfer $69,277 from measures specified in budget table.
5.3.3/5.4.3 Management of Floating Vegetation Mats and Litter

Long-term Objective:
Minimize impacts of floating vegetation and litter on TWR stands and overall aquatic community within the San Marcos River, as well as keep springs clear to enhance San Marcos salamander habitat.

Existing vegetation management activities in Spring Lake will continue to follow the Spring Lake Management Plan (approved by the President’s Cabinet) and the EAHCP, as described under Methodology.

Target for 2020:
Management activities include removal of litter from the littoral zone, stream bottom and portions of the major tributaries, and vegetation mats from Spring Lake Dam reach to IH-35.
The Meadows Center team removes floating mats from the entire reach they are working. Texas State University will manage aquatic vegetation in Spring Lake through use of its harvester boat and trained divers authorized to dive in Spring Lake.

Methodology:
*Spring Lake:* Each week about five springs are gardened, with divers returning to garden the same springs every two to three weeks. During summer algal blooms, the springs are managed more frequently (up to four springs per day), primarily to remove algae. Texas State employees and supervised volunteers fin the area around the springs to remove accumulated sediment, and then clear a 1.5 meter radius around each spring opening in Spring Lake with a scythe. Over the next 1.5 meter radius around the spring opening, they shear vegetation to a height of 30 cm, and then to one meter over the following three meter radius. Plant materials are not collected, but rather carried away by the current. Cumulatively, about six meters of vegetation around each spring opening is modified. Mosses are not cut. The volume of plant material to be removed will vary by the amount of time between cuttings and season. The harvester boat will remove a range of 15 to 20 boatloads of plant material a month from Spring Lake. The harvester clears the top meter of the water column, cutting vegetation from sections one, two, and three once a week (See HCP Figure 5-2). The harvested vegetation is visually checked by the driver for fauna caught in the vegetation. If the driver observes fauna, he/she will stop work and return the animal(s) back into Spring Lake if appropriate. Texas State employees and supervised volunteers are trained to recognize the Covered Species through the Diving for Science program (Section 5.4.7.1), and avoid contact with them. Vegetation mats are removed from zones four and five on an as-needed basis (See HCP Figure 5-2). The total area cut equals about nine surface acres. The Spring Lake Area Supervisor also schedules cleanup of nuisance floating species such as water hyacinth and water lettuce from Spring Lake. The floating plants are collected by hand and shaken prior to removal from the river to dislodge any aquatic species caught in the plant. The plants are deposited into dump trucks and taken to the MCWE compost area. The activities described in this section are not funded by the EAHCP. They are fully supported by Texas State University.

*San Marcos River:* Floating vegetation in Texas wild-rice stands is lifted off the stands and removed. Inorganic litter is picked up weekly from the substrate, surface and littoral zones of the
San Marcos River from Clear Springs Natural Area to City Park and from IH-35 to Stokes Island during the recreational season (May 1st to September 30th) and monthly during offseason. Litter is also removed from public lands within the four tributaries.

**Monitoring:**
In the event of low flows, this activity will be monitored by the EAA contractor for potential impacts on listed species and will be suspended if impacts are observed. Volume of litter removed will be tracked. Removal of vegetation mats will be tracked with polygons delineating work areas and attribute data that include date, location, and percent species composition.

**Budget:**
Table 7.1:
$80,000

Available budget for 2020:
$80,000*

Estimated 2020 budget:
$44,688*

*$35,312 to be transferred to Control of Non-native Plant Species
5.3.5/5.3.9/5.4.11/5.4.13 Non-Native Species Control

Long-term Objective:
Reduction of non-native, invasive species in the San Marcos River to levels that minimize their possible impacts on Covered Species and the aquatic ecosystem.

Target for 2020:
Contractor will use methods that have proven to be successful in efficient removal of invasive species from Spring Lake to IH-35. Contractor will measure length and weight for fish species. The targeted species include suckermouth catfish, tilapia, nutria and two snail species, *Melanoides* and *Marisa cornuarietiis*.

Methodology:
Fyke nets, spear and bow fishing continue to be effective methods for fish removal. Contractor uses spearfishing tournaments, permitted through the municipality, to increase total removal, while saving costs and providing an educational awareness component to participants. Contractor ensures that all methods avoid impacts to resident turtles and other native species.

Effective removal of *Melanoides* and *Marisa cornuarietiis* is accomplished by determining the locations of highest snail density and using dip nets to remove the snails weekly. These species are best controlled by diving several hours after sunset to hand-pick the snails from the substrate and SAV.

Box traps baited with carrots, sweet potatoes, and apples will be used to capture nutria. Traps will be placed in areas frequented by nutria. The traps will be checked in the late afternoon and again the next morning at about 0730. Captured nutria will be euthanized. Removed nutria will be measured and weighed prior to being disposed of.

City of San Marcos has an ordinance prohibiting the dumping of aquaria into the San Marcos River (Sec. 58.037) and accepts unwanted aquatic fauna at the Discovery Center.

Monitoring:
In order to monitor the reduction of overall non-native species abundance in the San Marcos ecosystem, the COSM and TXSTATE will compile information regarding the size (weight and total length) of the individual animals removed. This information may assist in determining overall effectiveness of this conservation measures impact of species population dynamics.

Budget:
Table 7.1:
$35,000
Available budget for 2020:
$35,000
Estimated 2020 budget
$27,285*
*$7,715 to be transferred to Control of Non-native Plant Species
5.3.7 Designation of Permanent Access Points/Bank Stabilization

Long-term Objective:
Maintain integrity of structures that serve to control bank erosion, protect Texas wild-rice and listed species habitat in the recreation traffic areas.

Target for 2020:
The City of San Marcos completed the construction of bank stabilization/access points at seven locations along the San Marcos River in 2014 with repairs made in 2017.

Monitoring:
A diver will measure possible undermining at each site twice yearly. The surface of each site will also be inspected for damage.

Budget:
Table 7.1:
$20,000

Available budget for 2020:
$0

Estimated 2020 budget:
$0
5.7.1 Native Riparian Habitat Restoration

Long-term Objective:
Establish a robust native riparian and water quality buffer community that benefits Covered Species through increasing the habitat and water quality within the San Marcos River down to city limits. The buffer will also prevent public access which causes bank erosion and impacts TWR stands. A zone of prohibitive vegetation along the uppermost edge of the riparian and water quality buffer community will be established to encourage river users to access the river via hardened access points. Private riverside landowner participation in this program will be encouraged and the EAHCP will provide the labor and plants as practical. EAHCP-funded contractor(s) will perform invasive removal and maintenance. Native plantings and maintenance will be done by volunteers during regular planting events.

Target for 2020:
Contractor (funded through the EAHCP and COSM) and volunteers will maintain all treated areas from Spring Lake to Stokes Park, and any new adjacent areas to address invasive regrowth and/or seedbank source as appropriate. Volunteers plant natives in previously worked areas during regular planting days as needed. Initial invasive removal has been completed from headwaters to Thompson’s Island, so maintenance of all treated areas and initial removal from Thompson’s to Stokes will be the primary focus with secondary seed source removals.

Methodology:
Contractor removes and treats invasive regrowth using a glyphosate/trichlopyr herbicide mix to treat the stumps and/or roots. On upland trees, shrub stumps and root buttresses, Relegate (Triclopyr-based herbicide) is used. The Relegate is mixed with glyphosate, Drexel Surf Ac 820 Surfactant and Turf Mark Blue, a blue dye. Roots are scraped and treated with herbicide mix then monitored. Volunteers complete all other native riparian habitat restoration as described above using plants propagated at the Discovery Center. Treated and adjacent areas will be monitored for re-growth and seed sources.

Monitoring:
Monitoring will occur monthly to check for re-growth and treat as needed. Maintenance will continue to be a mix of contract work funded by EAHCP and COSM, as well as volunteerism. The City will continue to provide all fences to protect the sites as well as game cameras and other security measures as needed to prevent theft, vandalism and unauthorized access.

Budget:
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5.3.2/5.4.2 Management of Recreation in Key Areas

Long-term Objective:
To minimize the impacts of incidental take resulting from recreation which includes, but is not limited to swimming, wading, tubing, boating, canoeing, kayaking, golfing, scuba diving, snorkeling and fishing.

Target for 2020:
1. Hire 10 Conservation Crew members that work 16 hours/week (Wed to Sun) from May to September with 2 – 3 members working prior to summer season and after to continue public outreach, recreation impact minimization efforts, and assists the MCWE HCP team in their efforts to remove floating plants mats and non-native vegetation.

2. Continue the implementation of the following recreational management goals at a minimum:
   a. Signage. Signs have been posted in kiosks at most of the river access points. Signs cover the rules of the river and educate the public on the importance of the resource.
   b. Video Loop at City Park and Rio Vista Falls offering information about the river and safety rules while people are waiting for shuttle or tubes. Video was finished and installed in 2016/2017 for Lion’s Club and will be updated and distributed electronically for increased exposure.
   c. Posted maps showing trail, access points, fishing access and other amenities. River maps are located at the Discovery Center which serves as the trailhead to the San Marcos River and help inform visitors and recreationists about the San Marcos River/Blanco confluence.
   d. Work with the Tourist Information Bureau (TIB) to include information on the endangered species and ongoing HCP projects at hotels/restaurants, bed and breakfast facilities, Chamber of Commerce, Visitor’s Center, City of San Marcos internet site, etc. along with the recreational information. EAHCP brochures have been placed at the TIB for visitors and associated facilities.
   e. Park Rangers. Training materials covering the river flora and fauna have been developed and provided for the training of the park rangers, so they can help disseminate the information.
   f. School Outreach. Implement an outreach program for San Marcos Consolidated Independent School District (SMCISD) so this information can be relayed to youth in San Marcos and indirectly to the parents. The San Marcos Discovery Center is a facility dedicated to public education and outreach regarding the San Marcos River. Outreach efforts include the production of an interactive river habitat card game that was introduced into the curriculum for SMCISD elementary schools.
g. Continue to provide EAHCP presentations to TXST Outdoor Recreation class and Wildlife Society club and partner with TXST Geography Intern Program to increase volunteer participation.

h. Continue to provide outreach at booths including Concert Series (Earth & Water), Passport SMTX, Business Expo, Mermaid Society events, San Marcos Sustainability Fair, and Don’t Mess with Texas Litter Cleanup.

j. Continue to educate the public during volunteer planting days.

k. Continue to educate the public engaged in water-based recreation on sustainable river behaviors that protect listed species and their habitats through interns and Conservation Crew program.

l. Introduce the COI program to qualified third parties conducting recreational activities in and along the San Marcos River.

m. Monitor and educate recreationists about the invasive zebra mussels.

**Monitoring:**
Litter removed from the river during the recreation season is tracked. Also, the Conservation Crew will monitor boats and river structures for the presence of zebra mussels from Spring Lake Dam to IH-35.

**Budget:**
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5.7.6 Impervious Cover/Water Quality Protection

Long-term Objective:
The EAHCP commitment for a combined effort (Sediment Management and Impervious Cover & Water Quality Protection) includes construction of Sessom Restoration Phase 1 starting fall of 2020.

The most cost-effective strategy identified under the AMP was implementation of stream restoration projects in the middle reach of Sessom Creek. Restoration will also address a tributary flowing into the middle reach, the Windmill Tributary, that is experiencing accelerated stream erosion and also contributing high sediment loads. Primary objectives of the AMP strategies are (1) reduce existing stream erosion, and (2) accelerate the natural re-stabilization process for Sessom Creek, i.e., to return it to a state of geomorphic equilibrium.

The preliminary recommendations address Phase 1, approximately 1400 linear feet of Sessom Creek, from above North LBJ Drive upstream to the Windmill Tributary confluence and Phase 2, approximately 565 linear feet from the confluence to the Loquat/Canyon intersection, plus 550 linear feet of Windmill Tributary. A future Phase 3 addresses Sessom Creek above the Loquat/Canyon intersection (an additional 800 linear feet) (Figure 6). Stream and watershed restoration practices identified for each project reach include grade control, bank stabilization, gully control, stormwater management ponds, natural channel design, and riparian restoration.

In addition, the City of San Marcos has identified several other projects and concerns within the same geographic area. These include wastewater improvements, road repair and improvements, site-specific erosion repairs, and a water main project. These improvements will work in concert with the stream restoration and stormwater management practices to the maximum extent practical. The wastewater improvement project is separate but is planned to occur concurrently with the other projects.
Target for 2020:
Complete bid preparation for Phase 1 and begin construction in the fall. Phases 2 & 3 will begin construction in 2021. Continue working with TXST to control sediment loss into Sessom Creek from campus sites.

Monitoring:
Water quality monitoring program managed by the EAA will set the pre-construction parameters. The EAA Sessom Real-Time station and the applied research water quality sampling at the Freeman Aquatic Building will supply the data.

Budget:
Table 7.1
$200,000

Available budget for 2020:
$225,000

Estimated 2020 budget:
$200,000*

*$1,528,200.00 was approved for this conservation measure in 2019. $1,528,200.00 is expected to be spent from 2019 through 2023. As of the May 2019, the City of San Marcos has invoiced $99,344 for reimbursement.
from the EAHCP toward this conservation measure. Designs for stream restoration on Sessom Creek are scheduled for completion in 2019 with a total estimated design cost around $645,000. Construction funds will be included in future funding applications when the construction bids are tabulated.
5.7.5 Management of Household Hazardous Waste

Long-term Objective:
Strengthen the COSM existing program that provides a place for citizens of San Marcos and Hays County to safely dispose of HHW. This prevents the dumping of HHW into the river or recharge zone and thus impacting listed species.

Target 2020:
Target 3000 participants for public outreach events. Staff will conduct these events and convert or dispose of the HHW between events. Fund outreach to surrounding communities within the San Marcos River watershed that cannot afford to partner in a HHWC program. Mailing quick fact flyers out with HHW information.

Methodology - open drop-off opportunities two days a week (Tuesday and Friday) from 12:00 noon to 3:30 p.m. to the public.

Monitoring:
Track the amount of HHW received and number of participants from San Marcos, Hays County, and surrounding communities. All necessary documentation will be turned in to TCEQ. Identify the HHW that comes from communities with the San Marcos River watershed and the cost of collecting, processing and disposing of HHW from these communities.

Budget:
Table 7.1:
$30,000

Available budget for 2020:
$30,000

Estimated 2020 budget:
$30,000
5.3.4 Prohibition of Hazardous Materials Transport Across the San Marcos River and Its Tributaries

**Long-term Objective:**
Reduce the potential of spill of hazardous materials in the San Marcos River and its tributaries through the designation of a hazardous materials route in COSM.

**Target for 2020:**
Produce map with TxDOT limitations and obtain TxDOT approval.

**Monitoring:**
Bi-annual monitoring of hazmat traps on designated roadways to determine functionality and annual monitoring of all installed signage is ongoing. Substandard conditions will be repaired or replaced as necessary.

**Budget:**
Table 7.1:
$0

Available budget for 2020:
$0

Estimated 2020 budget:
$0
5.7.3 Septic System Registration and Permitting Program

Long Term Objective:
To ensure an aerobic and anaerobic septic system registration, evaluation, and permitting program to prevent subsurface pollutant loadings from potentially being introduced to the San Marcos Springs ecosystem within city limits.

Target for 2020:
To have an accurate record of new and existing septic systems installed and modified in city jurisdiction. In addition, city ordinance requires all owners of septic systems connect to municipal sewer lines as they become available.

Methodology - it is required by law that all septic systems are permitted by the local Designated Representative (DR), which is the City of San Marcos Environmental Health Department. Plans are submitted with the application and reviewed by the DR for TCEQ compliance. Once these requirements are met, the permit to construct is issued. The design, site evaluation, installation and inspections can only be performed by individual that are licensed by TCEQ. Before the installation or modification is approved, inspections are made by the DR to ensure that the system installed corresponds with the design. Once completed, a license to operate is issued to the property owner by the DR. All DRs are subject to TCEQ Compliance Reviews.

Monitoring:
The City of San Marcos Environmental Health Department reviews all applications and inspects the installations of all new and modified septic systems within the City’s jurisdiction. The Department also monitors maintenance and responds to all complaints reported or observed.

Budget:
Table 7.1:
$0

Available budget for 2020:
$0
5.7.4 Minimizing Impacts of Contaminated Runoff

**Long-term Objective:**
The goal of this measure is to reduce the input of sediment and roadway contaminates into the San Marcos River. In order to leverage existing investment from the COSM, the EAHCP will assist in completing two ponds currently under construction. Both ponds are designed for high pollutant load reduction and have been identified as a priority management strategy.

**Target for 2020:**
All activities and funds associated with this measure have been completed

**Budget:**
Table 7.1:
$0

Available budget for 2020:
$0
5.4.5 Diversion of Surface Water

Long-term Objective:
Texas State University will curtail its permitted surface water diversions as a function of total San Marcos spring flow to protect the aquatic resources as specified under the HCP flow management strategy. Meet diversion restrictions specified under the HCP.

Target for 2020:
Restriction of surface pumping as specified under the HCP. Under TCEQ Certificates 18-3865 and 18-3866, Texas State University’s total diversion rate from the headwaters of the San Marcos River for consumptive use is limited to 8.1 cfs (See HCP Section 2.5.5). The total diversion rate from Spring Lake is limited to 4.88 cfs; the total diversion rate from the San Marcos River at Sewell Park is limited to 3.22 cfs (See HCP Section 2.5.5.1 and 2.5.5.2 respectively).

Methodology - when flow at the USGS gauge at the University Bridge reaches 80 cfs, Texas State University will reduce the total rate of surface water diversion by 2 cfs, i.e., to a total of approximately 6.1 cfs. This reduction in pumping will occur at the pump just below Spring Lake Dam in order to maximize the benefits to salamanders, Texas wild-rice, and other aquatic resources in the San Marcos River below Spring Lake Dam. The University will reduce the total rate of surface water diversion by an additional 2 cfs when the USGS gauge reaches 60 cfs. The additional 2 cfs reduction will be made from the pumps located in the slough arm of Spring Lake, and, therefore, maximize the benefits to the aquatic resources within the main stem San Marcos River below Spring Lake Dam. When the USGS gauge reaches 52 cfs, Texas State University will reduce the total diversion rate to 1 cfs. This further reduction will be made by restricting the pumps located in the Sewell Park reach. The diversion of water will be suspended when the springflow reaches 45 cfs.

Monitoring:
Pumping rates will be reported on a daily basis when any of the pumping restrictions are in force.

Budget:
Table 7.1:
$0

Available budget for 2020:
$0
5.4.7 Diving Classes in Spring Lake

**Long-term Objective:**
Maintain the integrity of the ecology within Spring Lake through controlling access to Spring Lake in accordance to federal, state and local laws.

*Assumptions:* All diving activities in Spring Lake are governed by the Spring Lake Management Plan.

**Target for 2020:**
Implement the diving protocols as outlined in the Spring Lake Management Plan and the Edwards Aquifer HCP Incidental Take Plan with the following modifications: No more than 20 volunteer divers will be allowed in the lake per day, with not more than ten at one time.

**Methodology** - the Diving Safety Officer will monitor all diving activities in Spring Lake, assuring all guidelines contained in the Diving Safety Manual for Spring Lake and the EAHCP ITP are observed.

**Monitoring:**
The Lake Manager, with assistance from the Diving Safety Officer, will compile an annual summary of diving activities conducted in Spring Lake and provide to the Diving Control Board for its review.

**Budget:**
*Table 7.1:*
$0

*Available budget for 2020:*
$0
5.4.8 Research Programs in Spring Lake

City ordinance and state law designate the public waters of Spring Lake as restricted to activities authorized by the University. Proposals for research projects in Spring Lake must be submitted to the Environmental Review Committee, through the Lake Manager, for review and approval.

**Long-term Objective:**
Maintain the integrity of the ecology within Spring Lake through controlling access to Spring Lake in accordance to federal, state and local laws. All research activities in Spring Lake are governed by the Spring Lake Management Plan.

**Target for 2020:**
Implement the protocols for research as specified in the Spring Lake Management Plan and the EAHCP ITP.

**Methodology** - Proposals for research projects in Spring Lake must be submitted to the Environmental Review Committee, through the Lake Manager, for review and approval.

Proposals for research projects must be submitted in writing and include:

1. Name and contact information of the responsible party conducting the research,
2. Purpose and expected outcomes of the activities, including a description of how the project contributes to science,
3. Description of activities, including, if appropriate, measures to be taken to minimize any impact on endangered species or their habitat, or any cultural resources found in the lake,
4. Methodology, including literature review,
5. Type of equipment used, how much; where it will be placed, and for how long it will remain in lake (see Equipment in Lake Section E of the Spring Lake Management Plan)
6. Expected impact, and
7. Timeline of Project

**Monitoring:**
The Lake Manager will compile an annual summary of the research conducted in the lake, including statements on the impact of these activities on the health of the lake.

**Budget:**
Table 7.1:
$0

Available budget for 2020:
$0
5.4.10 Boating in Spring Lake and Sewell Park

Long-term Objective:
Maintain the integrity of the ecology within Spring Lake and San Marcos River through controlling access to Spring Lake in accordance to federal, state and local laws. All boating activities in Spring Lake are governed by the Spring Lake Management Plan and the EAHCP ITP.

Target for 2020:
Implement the protocols for boating as specified in the Spring Lake Management Plan in support of the EAHCP ITP.

– Follow the below protocol for all boats (canoe, kayak, and paddleboards) used for educational activities, excluding glass bottom boats:

1. All boats must be properly washed/disinfected before being placed in lake and once they are removed (see Equipment in Lake in the Spring Lake Management Plan).
2. Participants must receive an orientation prior to boating including: instruction on safety, basic boat handling, and on-site rules and regulations. The orientation will cover information specific to Spring Lake’s sensitivity and endangered species.
3. All boating events must be designed to keep participants away from glass bottom boat operations.

To minimize the impacts of boating on the Covered Species’ habitat in Sewell Park, canoeing/kayaking classes in Sewell Park will be confined to the region between Sewell Park and Rio Vista dam. Students will enter/exit canoes/kayaks at specified access points to avoid impacting the flora and fauna along the bank. Classes will be no longer than two hours and up to three classes will be held per day. Classes will have a maximum of 20 students. All classes will be supervised.

Monitoring:
The Lake Manager will compile an annual summary of boating activities conducted on the lake, including statements on the impact of these activities on the health of the lake.

Budget:

Table 7.1:
$0

Available budget for 2020:
$0
5.4.9 Management of Golf Course and Grounds

**Long-term Objective:**
Management of the grounds to minimize and reduce negative effects to aquatic ecosystem in Spring Lake and the San Marcos River.

**Target for 2020:**

**Methodology** - the grounds will be maintained to meet the recreational function, yet in an environmentally sensitive manner. It is the responsibility of the Manager to maintain the grounds in accordance with the Integrative Pest Management Plan (IPM). This plan will describe the activities and materials to be used to control pests (i.e. insects, weeds, and other living organisms requiring control) in a way that minimally impacts the environment. The IPM updated as needed by the Grounds Manager, in consultation with the Lake Manager and the Environmental Review Committee. The Grounds Manager will consult with the Lake Manager on any unique situation that may arise outside of routine maintenance that could impact Spring Lake.

**Monitoring:**
Each year the Grounds Manager will report to the Lake Manager detailed information on maintenance activities and materials used during the year.

**Budget:**
Table 7.1:
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**Available budget for 2020:**
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City of New Braunfels
2020 EAHCP Work Plan
## 2020 City of New Braunfels Work Plan Budget

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<sup>a</sup> The $50,000 increase in the estimated budget for Task 5.2.2.2 is offset by the $50,000 decrease for Task 5.2.2.1.  
<sup>b</sup> Funds for these measures will be expended only if low-flow conditions (<100 cfs) are realized at Comal Springs.  
<sup>c</sup> Funds from Task 5.2.6 ($15,000) and Task 5.2.8 ($15,000) will be reallocated to fund Task 5.2.10.  
<sup>d</sup> Funds from Task 5.2.6 ($50,000) will be reallocated to fund a portion of Task 5.7.1.  
<sup>e</sup> Funds from Task 5.2.5 ($8,000) will be reallocated to fund a portion of Task 5.7.5.  
<sup>f</sup> The increase in Task 5.7.6 available budget is the result of a rollover of unspent funds from 2019 ($55,000) to 2020.
5.2.1 Flow Split Management

Long-term Objective:
To sustain flow rates in the Old Channel of the Comal River that compliment Old Channel aquatic vegetation restoration efforts, minimize channel scouring, and maximize the quality of fountain darter habitat.

Target for 2020:
Maintain flow rates in the Old and New Channels of the Comal River to meet objectives specified in the revised Table 5-3 of the EAHCP (Table 1).

Priority will be given to achieving target flow rates in the Old Channel and, secondly, to flow rates in the New Channel. City of New Braunfels staff will monitor streamflow conditions via USGS streamflow gages and operate the flow-control gate between Landa Lake and the Old Channel to achieve flow targets. Maintenance activities associated with the flow-control gates will be conducted as needed to ensure continued operability.

Table 1. EAHCP Table 5-3 (revised)

<table>
<thead>
<tr>
<th>Total Comal Springflow (cfs)</th>
<th>Old Channel (cfs)</th>
<th>New Channel (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall, Winter</td>
<td>Spring, Summer</td>
</tr>
<tr>
<td>350+</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td>300</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td>250</td>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td>200</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>150</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>70</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>60</td>
<td>35-40</td>
<td>50</td>
</tr>
<tr>
<td>50</td>
<td>35-40</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

Methodology:
The City of New Braunfels will manage the flow-split program according to flow rates specified in revised Table 5-3. A standard operating procedure has been developed by the City of New Braunfels to guide adjustments to the flow-control gate and to achieve flow-split targets. City of New Braunfels staff will monitor real-time streamflow conditions at USGS gages in the Comal River system and adjust the flow-control gates, as needed, to meet flow-split streamflow targets. The primary 48” culvert gate and the new back-up culvert gates will be operated conjunctively to meet target flow rates. Floating vegetation and debris will be manually removed from the control gate and screen from a canoe or boat. Vegetative material removed from the intake structure will be placed along the banks of Landa Lake and/ or returned to Landa Lake. Floating vegetation is managed and funded under task of 5.2.10: Litter and Floating Vegetation Management. The flow control gate will be exercised routinely to maintain functionality of the gate.
**Monitoring:**
Flow rates in the Old Channel, New Channel, and Comal River will be based on real-time streamflow data provided by the USGS gages in the Comal River. City of New Braunfels staff will monitor streamflow on a weekly basis, at minimum. Adjustments to the flow-control gate will be made on an as-needed basis to meet flow-split management objectives. City of New Braunfels staff will monitor the flow-control gate and intake screen on a regular basis to assess for vegetation build-up and debris that have the potential to restrict flow into the culvert between Landa Lake and the Old Channel. When required, trash racks and vegetation barrier booms will be cleaned to prevent accumulations of vegetation and debris. Accumulated vegetation will be placed along the banks of Landa Lake and/or returned to Landa Lake.

**Budget:**
Table 7.1:
$0

Available budget:
$0

Estimated 2020 budget:
$0
5.2.2.1/ 5.2.2.3 Old Channel Aquatic Vegetation Restoration and Maintenance

**Long-term Objective:**
To achieve native aquatic vegetation coverage goals for the Old Channel Long-Term Biological Goal (LTBG) reach and the Old Channel Environmental Restoration & Protection Area (ERPA) reach as set forth in the revised EAHCP tables 4.1 and 4.1.1, respectively. The overall intent of the native aquatic vegetation restoration program is to provide and increase coverage of high quality habitat for the fountain darter.

**Target for 2020:**
Efforts in 2020 will include the planting of target native aquatic vegetation to achieve annual aquatic vegetation restoration goals and to maintain existing target aquatic vegetation coverage. **Figure 1** illustrates the Comal River system and identifies the individual Old Channel restoration reaches. The 2020 annual aquatic plant restoration goals, as well as the EAHCP long-term aquatic vegetation coverage goals, for the Old Channel LTBG reach and the Old Channel ERPA are specified by reach and vegetation type in **Table 2**. Continued efforts will also be made in 2020 to remove re-emergent non-native *Hygrophila* from the Old Channel LTBG reach and the Old Channel ERPA.

**Figure 1:** Long-term biological goal reaches and restoration reaches for the Comal System. The Old Channel ERPA restoration reach is shown in green. The Old Channel LTBG reach is shown in red.
**Table 2:** Annual and long-term aquatic vegetation restoration goals, in meters squared (m^2), within Old Channel LTBG & ERPA restoration reaches.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Aquatic Vegetation Species</th>
<th>Meters squared of aquatic vegetation (m^2)</th>
<th>Annual Restoration Goal</th>
<th>Approximate # of plantings needed to meet annual goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Long-term Goal</td>
<td>2020</td>
<td>2020</td>
</tr>
<tr>
<td>LTDBG Reaches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old Channel</td>
<td><strong>Ludwigia</strong></td>
<td>425</td>
<td>75</td>
<td>1,125-1,500</td>
</tr>
<tr>
<td></td>
<td><strong>Cabomba</strong></td>
<td>180</td>
<td>25</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td><strong>Sagittaria</strong></td>
<td>450</td>
<td>50*</td>
<td>600</td>
</tr>
<tr>
<td>Restoration Reaches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old Channel ERPA</td>
<td><strong>Ludwigia</strong></td>
<td>850</td>
<td>0**</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>Cabomba</strong></td>
<td>200</td>
<td>0**</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>Sagittaria</strong></td>
<td>750</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>Vallisneria</strong></td>
<td>750</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>Potamogeton</strong></td>
<td>100</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

*Sagittaria* coverage will be monitored and planting will be given low priority given its propensity to naturally expand.

**Supplemental plantings of Ludwigia and Cabomba will be planted in existing restoration plots in the Old Channel ERPA, as necessary, to maintain existing coverage and/or to replace any drastic losses in coverage due to floods, natural competition or other factors.

**Methodology:**

*Non-Native Vegetation Management:*

Non-native aquatic vegetation (i.e. *Hygrophila*) has largely been removed from the Old Channel between Landa Lake and the downstream boundary of the Old Channel LTBG reach. Aquatic vegetation gardening will occur on a monthly basis in areas where non-native vegetation has previously been removed in order to identify and remove re-emergent non-native submerged aquatic vegetation (SAV). Small, localized growth of non-native SAV will be removed by selective physical extraction of visible plant and root mass.

*Native SAV Restoration:*

Target SAV species will be planted within the Old Channel LTBG reach to increase the coverage of individual aquatic plant species per the annual restoration goals set forth in **Table 2**. An approximate number of plants needed to achieve the annual goals is also included in **Table 2**. Individual plant species will be planted where planting space is available and in locations within the channel where light exposure, flow velocities, and substrate provide the most suitable conditions for the individual plant types. There are no annual restoration goals set forth for the Old Channel ERPA in 2020. Supplemental plantings of *Ludwigia* and *Cabomba* will be planted in existing restoration plots in the Old Channel LTBG and ERPA reaches, as necessary, to maintain existing coverage and/or to replace any losses in coverage due to floods, natural competition or other factors.

*Ludwigia* will continue to be propagated in-situ within Landa Lake to provide plant stock for 2020 restoration efforts. In-situ propagation of *Ludwigia* will be conducted by collecting stem cuttings from *Ludwigia* plants present within the Comal River system. The cuttings will be placed in pots filled with substrate collected from within the Comal River system. The potted cuttings are then
placed in Mobile Underwater Plant Propagation Trays (MUPPTs) that will be situated in a shallow portion of Landa Lake and allowed to produce roots and plant mass.

*Ludwigia* plants propagated in the MUPPTs, as well as *Ludwigia* cuttings, will be planted in suitable locations within the Old Channel LTGB reach to achieve an annual target of 75 m$^2$ of additional *Ludwigia* coverage. Slightly more than the targeted coverage of *Ludwigia* will be planted in order to account for plant die-off. Approximately 15-20 *Ludwigia* plants are needed to achieve 1m$^2$ of coverage. Therefore, approximately 1,125-1,500 *Ludwigia* plants will be planted in the Old Channel LTGB reach to achieve target annual coverage. Supplemental plantings of *Ludwigia* will be planted within existing restoration plots within the Old Channel ERPA, as needed, to maintain existing coverage of *Ludwigia*.

*Cabomba* typically thrives in deep, low-velocity areas and will be planted in the most suitable locations in the Old Channel LTGB reach to achieve an annual target of 25 m$^2$ of additional *Cabomba* coverage. *Cabomba* will be planted using stem cuttings and/ or with individual rooted plants. Stemmed cuttings will be collected from the New Channel and/ or the Spring-fed pool where *Cabomba* is abundant. The cuttings will be bundled into fist-sized bundles wrapped with rubber bands to keep bundles together. The *Cabomba* cutting bundles are typically 12 to 32 inches in length and will be planted at a depth of 2/3 their length, if possible, in soft, silty sediment. This planting depth prevents *Cabomba* from loosening and floating away and ensures multiple nodes are buried to encourage maximum development of root structure. Rooted *Cabomba* will also be utilized for planting. Rooted plants will be dug up individually from areas where *Cabomba* is abundant. The rooted plants will then be planted individually into silty streambed substrate. Both the stemmed cuttings and rooted plants will be planted in a grid-pattern at 1ft centers. Significantly more than the targeted coverage of *Cabomba* will be planted in order to account for plant die-off. Approximately 20 *Cabomba* plantings are needed to achieve 1m$^2$ of coverage. Therefore, approximately 500 *Cabomba* plants will be planted in the Old Channel LTGB reach. Supplemental plantings of *Cabomba* will be planted within existing restoration plots within the Old Channel ERPA, as needed, to maintain existing coverage of *Cabomba*.

*Sagittaria* coverage will be monitored throughout the year to determine the extent of natural expansion and whether planting to increase coverage is required. *Sagittaria* will be planted, as needed, in the most suitable locations in the Old Channel LTGB reach to achieve an annual target of 50 m$^2$ of additional *Sagittaria* coverage at full grow out. *Sagittaria* will be planted as transplants harvested from Landa Lake and other areas where dense *Sagittaria* stands exist. The leaves of the transplants will be trimmed prior to planting to decrease buoyancy and drag. A few *Sagittaria* plants can form a dense colony within several months. *Sagittaria* has been observed to be slightly tolerant of lower light levels allowing it to be planted in deeper water and in shady locations. Approximately 12 *Sagittaria* plants are needed to achieve 1m$^2$ of coverage. Therefore, approximately 600 *Sagittaria* plants will be planted in the Old Channel LTGB reach, as needed, to achieve target annual coverage.

Competition between native plants has been observed in the Old Channel where *Potamogeton* and *Sagittaria* have encroached on and taken over *Ludwigia* and *Cabomba* stands. To minimize the effects of competition and to promote the growth and spread of *Ludwigia* and *Cabomba*, buffers will be created around planted *Ludwigia* and *Cabomba* stands to the extent practicable. Any plant material that is removed during this activity will be collected and removed from the lake/ river. Priority will be given first to planting *Ludwigia* and *Cabomba* in areas that are expected to have minimal competition impact on these species.
Following planting of native SAV, monthly gardening and maintenance will occur between March and October to assess health of plants and to identify and remove any non-native vegetation that is beginning to establish within planting areas.

**Monitoring:**
As discussed in previous sections, areas where non-native vegetation removal has occurred will be routinely monitored for the re-establishment of non-native vegetation. Planted areas will also be monitored to assess expansion, die-off, and competition by non-native species. Once native aquatic vegetation is established in an area, monitoring will be conducted on a less frequent basis.

Vegetation mapping in both the Old Channel LTBG reach and the Old Channel ERPA will be conducted to evaluate SAV coverage and to assess the progress of aquatic vegetation restoration efforts. Mapping will occur in January, April, and October. The October mapping event will be used as a basis for assessing overall SAV coverage with respect to meeting long-term vegetation goals and developing annual restoration goals for 2021 and subsequent years.

**Budget:**
Table 7.1:
$100,000

**Available budget:**
$100,000

**Estimated 2020 budget:**
$50,000*

*The decrease of $50,000 in the budget for this task will be utilized for Task 5.2.2.2: Comal River/ Landa Lake Aquatic Vegetation Restoration.
5.2.2.2/5.2.2.3 Comal River/ Landa Lake Aquatic Vegetation Restoration and Maintenance

Long-term Objective:
To achieve native aquatic vegetation coverage goals for the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches as set forth in revised EAHCP tables 4.1 and 4.1.1, respectively. The overall intent of native aquatic vegetation plant restoration is to provide high quality habitat for the fountain darter.

Target for 2020:
Efforts in 2020 will include the planting of target native aquatic vegetation to achieve annual aquatic vegetation restoration goals and to maintain existing aquatic vegetation coverage. Figure 2 illustrates the Comal Springs/ River ecosystem and identifies the Landa Lake, New Channel and Upper Spring Run LTBG reaches as well as the Upper/ Lower Landa Lake restoration reaches. The annual aquatic plant restoration goals for the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches are specified by reach and vegetation type in Table 3. In addition to planting the target native aquatic plants to meet annual goals, continued efforts will be made in 2020 to monitor for the re-establishment of non-native *Hygrophila* in Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/ Lower Landa Lake restoration reaches. Any identified *Hygrophila* will be removed from the lake/ river.

![Figure 2: Long-term biological goal reaches and restoration reaches for the Comal System. The Upper and Lower Landa Lake restoration reaches are shown in light red and blue (respectively). The Landa Lake, New Channel, and Upper Spring Run LTBG reaches are shown in red.](image-url)
### Table 3: Annual and long-term aquatic vegetation restoration goals, in meters squared (m²), within Landa Lake, New Channel, and Upper Spring Run LTBG reaches and Upper/Lower Landa Lake restoration reaches.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Aquatic Vegetation Species</th>
<th>Meters squared of aquatic vegetation (m²)</th>
<th>Annual Restoration Goal</th>
<th>Approximate # of plants needed to meet annual goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Long-term Goal</td>
<td>2020</td>
<td>2020</td>
</tr>
<tr>
<td>LTBG Reaches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landa Lake</td>
<td>Ludwigia</td>
<td>900</td>
<td>105</td>
<td>1,575-2,100</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>500</td>
<td>30</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>2,250</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Vallisneria</td>
<td>12,500</td>
<td>75</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Potamogeton</td>
<td>25</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>New Channel</td>
<td>Ludwigia</td>
<td>100</td>
<td>15</td>
<td>225-300</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>2,500</td>
<td>20</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Upper Spring Run</td>
<td>Ludwigia</td>
<td>25</td>
<td>5</td>
<td>75-100</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>25</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>850</td>
<td>5**</td>
<td>60</td>
</tr>
<tr>
<td>Restoration Reaches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landa Lake Upper</td>
<td>Ludwigia</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>250</td>
<td>35</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>250</td>
<td>50**</td>
<td>600</td>
</tr>
<tr>
<td>Landa Lake Lower</td>
<td>Ludwigia</td>
<td>50</td>
<td>10</td>
<td>150-200</td>
</tr>
<tr>
<td></td>
<td>Cabomba</td>
<td>125</td>
<td>10**</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Sagittaria</td>
<td>100</td>
<td>25**</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td>Potamogeton</td>
<td>22,500</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Vallisneria will not be planted but will be allowed to naturally expand, as needed, to increase coverage.

**Based on previous mapping of SAV, coverages exceed the long-term coverage goal. SAV coverages based on Fall 2018 mapping will be used as a benchmark to determine if aerial coverage has fallen short of the long-term goals and whether planting will need to occur.

### Methodology:

**Non-Native Vegetation Management:**

Non-native aquatic vegetation (i.e. *Hygrophila*) will be removed, as needed, to minimize competition with native submerged aquatic vegetation (SAV). Large-scale removal of non-native SAV is not expected to occur in 2020 as non-native SAV has largely been eliminated from Landa Lake and the Upper Spring Run area. Restoration areas will be monitored for the re-establishment of non-native SAV. Small, localized growth of non-native SAV will be removed by selective physical extraction of visible plant and root mass.

**Native SAV Restoration:**

Target SAV species will be planted within the Landa Lake, New Channel, and Upper Spring Run LTBG reaches to increase the coverage of individual plant species per the annual restoration goals set forth in Table 3. An approximate number of plants needed to achieve the annual goals is also included in Table 3. Individual plant species will be planted in locations within the channel where light exposure, flow velocities, and substrate provide the best conditions for the individual plant types. Supplemental plantings of *Ludwigia* and *Cabomba* will be planted in existing restoration
plots within the Landa Lake, New Channel, and Upper Spring Run LTBG reaches, as necessary, to maintain existing coverage or to replace any drastic losses in coverage due to floods, natural competition or other factors.

*Ludwigia* will continue to be propagated in-situ within Landa Lake in order to provide plant stock for 2020 restoration efforts. In-situ propagation of *Ludwigia* will be conducted by collecting stem cuttings from *Ludwigia* plants that exist within the Comal River system. The cuttings will be placed in pots filled with substrate collected from within the Comal River system. The potted cuttings will then be placed in Mobile Underwater Plant Propagation Trays (MUPPTs) and placed in a shallow portion of Landa Lake and allowed to produce roots and plant mass. *Ludwigia* plants propagated in the MUPPTs, as well as *Ludwigia* cuttings, will be planted in suitable locations within the Landa Lake LTBG reach to achieve an annual target of 105 m$^2$ of additional *Ludwigia* coverage at full grow out, within the New Channel LTBG reach to achieve an annual target of 15 m$^2$ of additional *Ludwigia* coverage at full grow out, and within the Upper Spring Run LTBG reach to achieve an annual target of 5 m$^2$ of additional *Ludwigia* coverage at full grow out. *Ludwigia* plants and cuttings will also be planted in suitable locations within Lower Landa Lake restoration reach to achieve an annual target of 10 m$^2$ of additional *Ludwigia* coverage. Slightly more than the targeted coverage of *Ludwigia* will be planted to account for plant die-off. Based on previous restoration experience, approximately 15-20 *Ludwigia* plants are needed to achieve 1m$^2$ of coverage. Therefore, approximately 1,575-2,100, 225-300, and 75-100 *Ludwigia* plants will be planted in the Landa Lake LTBG, New Channel LTBG, and the Upper Spring Run LTBG reaches, respectively, to achieve target annual coverage in each reach. Approximately 150-200 *Ludwigia* plants will be planted in the Lower Landa Lake restoration reach to achieve target annual coverage in that reach.

*Cabomba* will typically thrive in deep, low-velocity areas and will be planted in the most suitable locations in the Landa Lake LTBG reach to achieve an annual target of 30 m$^2$ of additional *Cabomba* coverage at full grow out, within the New Channel LTBG reach to achieve an annual target of 20 m$^2$ of additional *Cabomba* coverage at full grow out and within the Upper Spring Run LTBG reach to achieve an additional 5 m$^2$ of *Cabomba* coverage at full grow out. *Cabomba* will also be planted in suitable locations within Lower Landa Lake restoration reach to achieve an annual target of 35 m$^2$ and 10 m$^2$ of additional *Cabomba* coverage, respectively. *Cabomba* will not be planting in the reaches where coverage has exceeded the long-term goal based on Fall 2018 SAV mapping. *Cabomba* will be planted using stem cuttings and/or individual rooted plants. Stemmed cuttings will be collected from the New Channel and/or the spring-fed pool. The cuttings will be bundled into fist-sized bundles wrapped with rubber bands to keep bundles together. The *Cabomba* cutting bundles are typically 12 to 32 inches in length and will be planted at a depth of 2/3 their length, if possible, in soft, silty sediment. This planting depth prevents *Cabomba* from loosening and floating away and ensures multiple nodes are buried for production of good root structure. Rooted *Cabomba* will also be utilized and will be harvested from areas in the Comal River system where *Cabomba* is abundant. The rooted plants will then be planted individually. Both the stemmed cuttings and rooted plants will be planted in a grid-pattern at 1ft centers. Significantly more than the targeted coverage of *Cabomba* will be planted in order to account for plant die-off. Approximately 20 *Cabomba* plantings are needed to achieve 1m$^2$ of coverage. Therefore, approximately 600, 400, and 100 *Cabomba* plants will be planted in the Landa Lake LTBG, New Channel LTBG, and the Upper Spring Run LTBG reaches, respectively, to achieve target annual coverage in each reach. Approximately 700 and 200 *Cabomba* plants will be planted in the Upper Landa Lake and Lower Landa Lake restoration reaches, respectively, to achieve target annual coverage in each reach.

*Sagittaria* will be planted, as-needed, in the most suitable locations in the Upper Spring Run LTBG, Upper Landa Lake and Lower Landa Lake reaches only on an as needed basis to achieve an annual target of 5m$^2$, 50m$^2$ and 25m$^2$ of additional *Sagittaria* coverage, respectively, at full grow out.
Sagittaria will not be planting in the reaches where coverage has exceeded the long-term goal based on Fall 2018 SAV mapping. Sagittaria will be planted as transplants harvested from Landa Lake. The leaves of the transplants will be trimmed prior to planting to decrease buoyancy and drag. Approximately 12 Sagittaria plants are needed to achieve 1m² of coverage.

Potamogeton will be planted in the most suitable locations in the Landa Lake LTBG reach to achieve an annual target of 5 m² of additional Potamogeton coverage at full grow out. Potamogeton will be planted using bare-root rhizomes that are harvested from the Comal River system. Approximately six rhizome sections need to be planted to achieve 1m² of Potamogeton coverage. Therefore, approximately 30 Potamogeton rhizomes will be planted in the Landa Lake LTBG reach to achieve the target annual coverage.

Competition between native plants has been observed where Vallisneria and Sagittaria will encroach on and take over Ludwigia and Cabomba stands. To minimize the effects of competition and to promote the growth and spread of Ludwigia and Cabomba, buffers will be created around planted Ludwigia and Cabomba stands to the extent practicable. Any plant material that is removed during this activity will be collected and removed from the lake/river.

Following planting of native SAV, gardening and maintenance will occur on a monthly basis between March and October to assess health of plants and to identify and remove any non-native vegetation that is beginning to establish within planting areas.

Monitoring:
Routine monitoring will occur in order to identify re-establishment of non-native aquatic vegetation. Planted areas will also be monitored to assess expansion, die-off, and competition by native and non-native aquatic plant species. Once native aquatic vegetation is established in an area, monitoring will be conducted on a less frequent basis.

Seasonal vegetation mapping in the Landa Lake, New Channel, and Upper Spring Run LTBG reaches and the Upper/Lower Landa Lake restoration reaches will be conducted to evaluate SAV coverage and to assess progress of aquatic vegetation restoration efforts. Mapping is conducted by circling the perimeter of vegetation stands with a kayak equipped with a Trimble GPS unit. Mapping will occur in January, April, and October. The October mapping event will be used as a basis for assessing overall SAV coverage with respect to meeting long-term vegetation goals and developing annual restoration goals for 2021 and subsequent years.

Budget:
Table 7.1:
$50,000

Available budget:
$50,000

Estimated 2020 budget:
$100,000*

*The increase of $50,000 in the budget for this task will be offset by a decrease in the budget for Task 5.2.2.1: Old Channel Aquatic Vegetation Restoration
5.2.3 Management of Public Recreation

Public recreational use of the Comal River ecosystems includes swimming, wading, tubing, boating, canoeing, kayaking, golfing, scuba diving, snorkeling and fishing. To minimize the impacts of incidental take resulting from recreation, the City of New Braunfels will continue to implement existing recreation control measures as specified in Section 5.2.3(1) of the EAHCP and will seek voluntary participation in the Certificate of Inclusion (COI) program from outfitters who facilitate recreation activities within the Comal River system.

Long-term Objective:
To minimize and mitigate the impacts of recreation on endangered species habitat within the Spring Runs, Landa Lake and the Comal River.

Target for 2020:
Continue to enforce existing restrictions that limit recreational access to Landa Lake, Spring Runs, and the Old Channel of the Comal River.

Inform river recreation Outfitters of the EAHCP COI program.

Methods:
The City will continue to enforce City Code Sections 86-4 and 142-5 that restrict recreational access to Landa Lake, Spring Runs, and the Old Channel. Trained Park Rangers will continue to patrol applicable areas to prevent illegal access to these waterbodies.

The City will continue to work in conjunction with EAHCP program staff to develop COI program documents and strategies. The City will reach out to local river outfitters to inform them of the COI program once a framework for the COI program is established. The COI will include the minimum requirements as specified in EAHCP § 5.2.3 (2) a-h.

Monitoring:
Monitor the status of participating outfitters to comply with the minimum COI outfitter standards and requirements set forth in Section 5.2.3 of the EAHCP.

Budget:
Table 7.1:
$0

Available budget:
$0

Estimated 2020 budget:
$0
5.2.4 Decaying Vegetation Removal and Dissolved Oxygen Management

Long-term Objective:
Maintain adequate dissolved oxygen (DO) levels within Landa Lake for the protection of the biological community, including the fountain darter. Minimize and mitigate oxygen consumption caused by decaying vegetation.

Target for 2020:
Collect DO data spatially throughout Landa Lake and the Upper Spring Run during low-flow periods (<100 cfs discharge at Comal Springs). Displace floating vegetation mats, as needed, that form on Landa Lake to prevent oxygen consumption by decaying vegetation (management of floating/decaying vegetation will be funded and accomplished through Task 5.2.10: Litter and Floating Vegetation Management). Remove decaying vegetation from Landa Lake and Upper Spring Run during low-flow conditions (<100 cfs), as needed, to mitigate low DO levels caused by low-springflow and decaying vegetation.

Methods and Monitoring:

Approximately six logging DO sensors (e.g., comparable to MiniDOT sensors available from Precision Measurement Engineering [PME Inc. Vista, CA] that have been used in prior years) will be installed in key documented fountain darter habitat areas in Landa Lake during periods when Comal Springs discharge decreases below 100 cfs. The sensors will be downloaded and cleaned routinely, as needed, to prevent fouling. The main objective of this 2020 data collection is to establish DO conditions during low-flow events and prompt DO mitigation activities.

Aquatic vegetation conditions and floating vegetation mats will be visually observed on a regular basis (i.e. weekly at minimum) to assess for signs of stress, die-off. Floating aquatic vegetation and dead aquatic vegetation has the potential to cause oxygen depletion from the decomposition of the vegetation itself and from reduced atmospheric reaeration. Should vegetation die-off be observed due to low-flow or if floating vegetation mats reach impactive levels (if mats cover >25% of the mid-lake area or if individual mats are >3 meters diameter), displacement or removal of the decaying vegetation or vegetation mats will take place within one week of identification as part of Task 5.2.10.

If low springflow conditions (<100cfs) occur and vegetation decay or low DO is evident, intensive displacement or removal of decaying vegetation will be implemented, as appropriate, under Task 5.2.10. Intensive refers to the frequency of vegetation mat management being more than once per week. Displacement and/or removal will be conducted in the least disruptive method tested to be effective, to limit any additional DO stress from stirring, turbidity, etc.

Budget:
Table 7.1:
$15,000

Available Budget
$15,000

Estimated 2020 budget:
$15,000*

*To be utilized only if low-flow conditions (<100cfs) are realized at Comal Springs.
Non-Native Animal Species Control

The City of New Braunfels will continue to implement a program to reduce non-native animal species in the Comal River system. The non-native animal species that will be targeted include the suckermouth armored catfish, tilapia, nutria, and ramshorn snail. Since this work plan has two components identified within the EA HCP, each component has been broken out to facilitate the development of the work plan and budgets.

Long-term Objective:
Reduce populations of non-native animal species to minimize their direct and indirect impacts to the Covered Species and the Comal River ecosystem.

Target for 2020:
Continue existing program to remove non-native invasive species, including tilapia, nutria, and suckermouth armored catfish from the Comal River system utilizing removal methods proven successful in previous years. Continue to record counts and biomass of removed species per removal effort.

Methods:
Invasive species including armored catfish, tilapia, and nutria will be removed from Landa Lake and portions of the Comal River during routine removal sessions. These sessions will occur year-round.

Tilapia and suckermouth armored catfish will be targeted throughout the Comal River system primarily by divers with spearguns. Gill nets will also be utilized for capturing tilapia and armored catfish within Landa Lake. Gill nets will be set primarily at the southern end of Landa Lake.

Upon removal from the water, all invasive fish will be eviscerated, in accordance with state laws and disposed of. The carcasses will be measured (in inches) and weighed (in pounds). Total biomass of the removed fishes will be calculated. Total length of non-native fishes will also be measured to determine if, over time, the removal of adults affects target population demographics.

Box traps baited with carrots, sweet potatoes, and apples will be utilized to capture nutria. Traps will be placed in areas frequented by nutria (evident by slides, scat, chewed vegetation, lake-wall erosion and damage, and other observations). The traps will be checked in the late afternoon and again the next morning at approximately 7:30 am. Captured nutria will be euthanized. Removed nutria will be measured (in inches) and weighed (in pounds) prior to being disposed of.

Monitoring:
Over the past few years, each fish species has shown a significant decrease in average length and weight as compared to 2013 data. This decrease in size may indicate that removal efforts are suppressing the population’s ability to gain adult mass and capacity to breed. The removal program will record following information:

- Date of removal.
- Number of hours worked.
- Type of species removed.
- Removal method.
- Number of individuals caught/speared.
- Total weight of individuals removed.
• Length of individuals removed.

The data provided will be used by EAHCP staff to generate catch per unit effort and determine the effectiveness of the removal program.

The EAA Biological Monitoring program will also assess the status of non-native species populations and any impacts of non-native removal to the Covered Species.

Reduction of Non-Native Species Introduction and Live Bait Prohibition

Long-term Objective:
Minimize the introduction of non-native species to the Comal River system.

Target for 2020:
The City will continue to work towards the development of an ordinance or other mechanism designed to control introductions of non-native aquatic organisms to the Comal River system. The ordinance or alternative mechanism will specifically address the usage of live bait and aquarium dumping.

Methods:
City staff will draft an ordinance prohibiting aquarium dumping and the possession of certain live bait species. The City will consult with Texas Parks and Wildlife Department on the regulation of live bait. The ordinance will be presented to City Council for consideration.

Monitoring:
The EAA Biological Monitoring program will detect the presence of newly introduced species.

Budget:
Table 7.1:
$75,000

Available budget:
$75,000

Estimated 2020 budget:
$50,000
5.2.6/6.3.6 Monitoring and Reduction of Gill Parasites

Long-term Objective:
To assess the threat of the gill parasite (*C. formosanus*) and *Haplorchis pumilio* on fountain darter populations by monitoring the host snail (*M. tuberculatus*) and parasite cercariae density and distribution in water column concentrations.

Target for 2020:
Perform gill parasite and *H. pumilio* cercariae water column concentration monitoring. Analyze monitoring data to determine the overall effect and potential threat of the parasites to fountain darter populations.

Methods:
To quantify the density of drifting parasite cercariae in the Comal River, three transects (LL, OCR, RVP) sampled in 2015-2019, plus an additional transect at Pecan Island in Landa Lake, will be sampled in 2020. Figure 4 illustrates the parasite cercariae monitoring locations (the fourth transect at Pecan Island not shown).

![Figure 4. Parasite cercariae monitoring locations](image)

At each of the selected transect locations, 5-L water samples will be collected from six points that are evenly distributed throughout the water column both horizontally and vertically. For each transect, three sampling stations will be established that are equally spaced across the stream channel perpendicular to flow. At each of these stations, two 5-L samples will be collected, one approximately 5 cm from the surface and one at 60% of the depth at that location. Samples will be collected using a modified livewell pump attached to a standard flow/depth measurement rod and buckets marked at the 5-L volume. At the time of collection, each water sample will be immediately treated with 5 milliliters (ml) of formaldehyde to kill parasite cercariae, thus facilitating their
capture (live cercariae can wiggle through the filter device). Filtration will involve passing the sample through a specialized filter apparatus containing three progressively finer nylon filters, the final filter having pores of 30 microns. After filtration of each sample, the 30-micron filter containing cercariae will be removed from the filtration apparatus and placed in a Petri dish. Each sample will then be stained with Rose Bengal solution and fixed with 10% formalin, at which point the Petri dish was closed and sealed with Parafilm for storage. Cercariae on each filter will later be counted using high-power microscopy at the BIO-WEST laboratory.

**Budget:**

Table 7.1:
$75,000

**Available budget:**
$75,000

**Estimated 2020 budget:**
$10,000
5.2.7 Prohibition of Hazardous Materials Transport Across the Comal River and Its Tributaries

The City of New Braunfels will continue to prohibit the transport of hazardous materials on routes crossing the Comal River and its tributaries.

**Long-term Objective:**
To minimize the potential for accidental spills or releases of hazardous materials into the Comal River system that may cause negative impacts to the Covered Species.

**Target for 2020:**
Maintain signage installed in 2016 and monitor for the presence of trucks carrying hazardous cargo on routes crossing the Comal River and its tributaries.

**Methods:**
City of New Braunfels Ordinance No. 93-7 effectively restricts the transport of hazardous cargo within Loop 337 and IH-35 and therefore, over roadways crossing the Comal River. Hazardous cargo route prohibition signage was installed in 2016 at key roadways near the headwaters of Landa Lake and the Comal River.

**Monitoring:**
Hazardous cargo restriction signage will be monitored and replaced/repaired as needed. The City of New Braunfels Police Department will monitor for trucks carrying hazardous cargo on prohibited routes per City ordinance.

**Budget:**
Table 7.1:
$0

Available budget:
$0

Estimated 2020 budget:
$0
5.2.8 Native Riparian Habitat Restoration (Comal Springs Riffle Beetle)

**Long-term Objective:**
Establish a healthy, functioning riparian area along Spring Run 3 and the western shoreline of Landa Lake to benefit the Comal Springs Riffle Beetle. Establish native riparian vegetation to increase the stability of the bank, decrease erosion/ sedimentation and increase the amount of available food sources (i.e. course particulate organic matter) for the riffle beetle.

**Target for 2020:**
Monitor and maintain previously restored riparian areas along Spring Run 3 and the western shoreline of Landa Lake. Plant additional native riparian plant species within the riparian buffer area, as needed, to increase the density of vegetative coverage in this area. Remove any re-emergent non-native vegetation and maintain erosion control berms.

**Methods:**
Monitor the riparian zone along Spring Run 3 and the western shoreline of Landa Lake twice/year, once in late spring/early summer (April-June) and once in the fall (October) to assess for the re-emergence of non-native vegetation and to monitor the status of native plants and erosion control berms.

Mechanically remove any observed re-emergent, non-native invasive plant species within the riparian zone along Spring Run 3 and along the western shoreline, as needed.

Plant supplemental native plants, as needed to increase density of riparian buffer area. Native plants will be selected based on root structure, light requirements, drought tolerance, growth habits and deer-resistance. Candidate native plant species may include, but will not be limited, to those in Table 4. Re-construct erosion control berms as-needed.

**Table 4. Candidate riparian plantings**

<table>
<thead>
<tr>
<th>Sun Species</th>
<th>Shade Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turks Cap (Malvaviscus arboreus var. drummondii)</td>
<td>Turks Cap</td>
</tr>
<tr>
<td>Frostweed (Verbesina virginica)</td>
<td>Frostweed (Verbesina virginica)</td>
</tr>
<tr>
<td>Yellow Bidens (Bidens laevis)</td>
<td>Emory Sedge (Carex emoryi)</td>
</tr>
<tr>
<td>Swamp Milkweed (Asclepias incarnata)</td>
<td>Boneset/ Mistflower (Ageratina havanensis)</td>
</tr>
<tr>
<td>Switchgrass (Panicum virgatum)</td>
<td>Elderberry (Sambucus canadensis)</td>
</tr>
<tr>
<td>Bushy bluestem (Andropogon glomeratus)</td>
<td>Giant spiderwort (Tradescantia gigantea)</td>
</tr>
<tr>
<td>Emory Sedge (Carex emoryi)</td>
<td>Texas aster (Symphyotrichum drummondii texanum)</td>
</tr>
<tr>
<td>Sweetscent (Pluchea odorata)</td>
<td>Red salvia (Salvia coccinea)</td>
</tr>
<tr>
<td>Elderberry (Sambucus canadensis)</td>
<td>Buttonbush (Cephalanthus occidentalis)</td>
</tr>
<tr>
<td>Yellow compass plant (Silphium integrifolium radulum)</td>
<td>Inland Sea Oats (Chasmanthium latifolium)</td>
</tr>
<tr>
<td>Texas bluebells (Eustoma exaltatum)</td>
<td></td>
</tr>
</tbody>
</table>

**Budget:**
Table 7.1:
$25,000

**Available budget:**
$25,000

**Estimated 2020 budget:**
$10,000
5.2.10 Litter and Floating Vegetation Control

Long-term Objective:
Minimize the impacts of floating vegetation mats and litter on aquatic vegetation and endangered species habitat in Landa Lake, the Spring Runs, and the upper portion of the Old Channel. Mitigate low dissolved oxygen levels in Landa Lake caused by decaying vegetation. Minimize shading of and negative impacts to aquatic vegetation caused by floating vegetation mats.

Target for 2020:
Dislodge floating vegetation mats and remove litter from applicable portions of the Comal River system to prevent negative impacts to flow control structures, aquatic vegetation, and endangered species habitat. In the event of low-flow conditions or receipt of depressed dissolved oxygen levels in Landa Lake, the removal of and/or increased efforts to dislodge floating vegetation mats will be initiated to prevent oxygen consumption by decaying vegetative material.

Methods:
Floating Vegetation Mat Management: Floating vegetation mats are commonly observed within Landa Lake and are composed primarily of macrophyte fragments, algae, bryophytes and terrestrial debris. The vegetation mats are naturally occurring and are the result of natural processes. Maintenance activities associated with floating vegetation mats in Landa Lake will involve dislodging floating mats and facilitating migration of the mats downstream of Landa Lake. Any litter found within floating vegetation mats will be removed prior to dislodging. Maintenance of floating vegetation mats will occur on a weekly basis between March and September and on an as-needed basis during the remainder of the year. Floating vegetation mats will be dislodged from flow control structures, the Three Islands area, fishing pier and other locations where vegetation mats accumulate and negatively impact native aquatic vegetation. Additional efforts to displace and/or remove floating and decaying vegetation will occur during low-flow conditions (<100cfs) and/or when low dissolved oxygen levels are observed in order to further mitigate impacts to dissolved oxygen and native aquatic vegetation.

Litter Management: (March 1st to October 30th). Litter pickup within the riparian zone along the Old Channel and the Spring Runs will occur on a bi-monthly basis (twice/month) between March 1st and October 30th. Litter will also be removed from within the Old Channel and Spring Runs to the extent that it can be removed with a 10ft trash grabber. Removed litter will be quantified and reported on a monthly basis.

Monitoring:
Monitor litter and floating vegetation mats in applicable areas on a weekly basis and more frequently if low-flow conditions occur. DO concentrations will be monitored by EAA and as part of Task 5.2.4 (Decaying Vegetation Removal and Dissolved Oxygen Mgmt). City staff will monitor contractor efforts and coordinate additional efforts when deemed necessary.

Budget:
Table 7.1:

| Available budget: | $0 |
| Estimated 2020 budget: | $30,000* (Funds from Task 5.2.6 [$15,000] and Task 5.2.8 [$15,000] will be reallocated to fund Task 5.2.10.) |
5.2.11 Golf Course Management and Planning

The City of New Braunfels will implement their existing Integrated Pest Management Plan (IPMP) for Landa Park Golf Course. This process will incorporate public input and the Golf Course Advisory Board. The golf course IPMP will incorporate environmentally sensitive techniques to minimize chemical application, continue to improve water quality, and reduce negative effects to the ecosystem. Expanded water quality sampling targeted at Golf Course operations will be conducted as described in Section of 5.7.2 of the EAHCP.

**Long-term Objective:**
To manage the golf course and grounds in a way that minimizes negative impacts to the aquatic ecosystem in Landa Lake and the Comal River.

**Target for 2020:**
Continue to implement the IPMP and update as needed.

**Methods:**
The golf course and grounds will be maintained in an aesthetically pleasing, yet environmentally sensitive manner. It is the responsibility of the Golf Course Manager to maintain the course and grounds in accordance with the new IPMP. The IPMP describes chemicals and methods for controlling pests (i.e. insects, weeds, and other living organisms requiring control) on the golf course in a way that does not negatively impact water quality or endangered species.

**Monitoring:**
The EAHCP Water Quality Monitoring Program includes base flow and storm sampling at designated locations along the Comal River both up- and downstream of the Landa Park Golf Course. Samples are analyzed for various herbicides and pesticides per the IPMP to control pests and weeds. Detections of any pesticides and herbicides utilized for golf course maintenance operations may warrant the need for revisions to the existing IPMP.

**Budget:**
- **Table 7.1:**
  $0

  **Available budget:**
  $0

  **Estimated 2020 budget:**
  $0
5.7.1 Native Riparian Habitat Restoration

Long-term Objective:
Increase the area and density of native riparian vegetation, reduce non-native riparian vegetation, and prevent streambank erosion in areas immediately adjacent to the Comal River and Landa Lake to compliment aquatic vegetation restoration efforts and to protect water quality.

Target for 2020:
Increase the coverage and density of native vegetation in the riparian zone along the banks of Landa Lake and the New Braunfels Utilities (NBU) Headwaters facility located at the confluence of Blieder’s Creek and the Upper Spring Run. (Figure 6).

Remove non-native riparian vegetation (i.e. Elephant Ears [Colocasia esculenta]) from the banks of Landa Lake in the vicinity of Spring Island and on property controlled by the Comal County Water Recreation District #1 (CCWRD#1) across from the “the Island” park (Figure 7) and plant native vegetation.
Maintain areas where non-native riparian vegetation were removed in previous years to prevent re-establishment. Monitor and maintain previously planted areas to promote establishment and growth of native vegetation. Maintenance of restored areas in Landa Park will include the installation of permanent fencing, as needed, to prevent disturbance of restored areas by park visitors.

**Methods:**

*Native Plant Restoration:*

Plant native riparian vegetation along the NBU Headwaters facility property located at the confluence of Blieders Creek and the Upper Spring Run of Landa Lake. Native plants will be selected based on sun exposure, proximity to the stream, growth habit, and ability to withstand deer browsing. Candidate native plant species may include those in Table 5 based on the success of previous restoration efforts. Native plant restoration along the banks of the NBU Headwaters property will include primarily the planting of potted plants.

Establish a riparian buffer zone along Landa Lake near the outflow to the Mill Race/ New Channel (Figure 6, right) by creating a riparian protection area. Currently, this area is largely denuded of vegetation with evidence of erosion. The riparian zone will be delineated, soil prepared/amended, and plants installed to establish riparian vegetation, minimize erosion and stabilize the banks. Soil
preparation will include soil scarification and the addition of compost material. Candidate native plant species may include those in Table 5 based on the success of previous restoration efforts. Native plant restoration in this area will include both planting of potted plants and distribution of a native seed mix. Permanent fencing will be installed around the perimeter of the riparian protection area to protect the riparian area and prevent disturbance by park visitors. Permanent protective fencing will also be installed around riparian protection areas that were established in 2019 to define these areas as “grow zones” and minimize disturbance by park visitors.

In the area of Spring Island and CCWRD #1 property, erosion control berms will be installed in locations where non-natives are to be treated. Following the treatment of non-native vegetation and erosion control berms, native plants will be installed. Native plants will be selected based on sun exposure, proximity to the stream, growth habit, and ability to withstand deer browsing. Plant restoration in this area will occur in small sections to ensure establishment of planted areas prior to expanding restoration efforts to adjacent areas. Candidate native plant species may include those in Table 5.

Table 5. Candidate riparian plantings

<table>
<thead>
<tr>
<th>Trees and Shrubs</th>
<th>Herbaceous</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Beautyberry (Callicarpa americana)</td>
<td>Coral Honeysuckle (Lonicera sempervirens)</td>
</tr>
<tr>
<td>Bald Cypress (Taxodium distichum)</td>
<td>Creeping Spotflower (Acmea repens)</td>
</tr>
<tr>
<td>Bee Brush (Eysenhardtia texana)</td>
<td>Emory Sedge (Carex emoryi)</td>
</tr>
<tr>
<td>Black Walnut (Juglans nigra)</td>
<td>Frog Fruit (Phyla nodiflora)</td>
</tr>
<tr>
<td>Burr Oak (Quercus macrocarpa)</td>
<td>Frostweed (Verbesina virginica)</td>
</tr>
<tr>
<td>Buttonbush (Cephalanthus occidentalis)</td>
<td>Horse Herb (Calyptocarpus vialis)</td>
</tr>
<tr>
<td>Elderberry (Sambucus canadensis)</td>
<td>Inland Sea Oats (Chasmanthium latifolium)</td>
</tr>
<tr>
<td>Eve’s Necklace (Styphnolobium affine)</td>
<td>Switchgrass (Panicum virgatum)</td>
</tr>
<tr>
<td>Fragrant Sumac (Rhus aromatica)</td>
<td>Texas Lantana (Lantana urticoides)</td>
</tr>
<tr>
<td>Green Ash (Fraxinus pennsylvanica)</td>
<td>Turks Cap (Malvaviscus arboreus var. drummondii)</td>
</tr>
<tr>
<td>Mexican Buckeye (Ungnadia speciosa)</td>
<td>Water Willow (Decodon verticillatus)</td>
</tr>
<tr>
<td>Mexican Plum (Prunus Mexicana)</td>
<td>White Boneset (Eupatorium serotinum)</td>
</tr>
<tr>
<td>Mountain Laurel (Sophora secundiflora)</td>
<td>Yellow Bidens (Bidens sp.)</td>
</tr>
<tr>
<td>Possum Haw Holly (Ilex ambigua)</td>
<td>Woodland Sedge (Carex blanda)</td>
</tr>
<tr>
<td>Red Buckeye (Aesculus pavia)</td>
<td>Zexmenia (Wedelia acapulcensis var. hispida)</td>
</tr>
<tr>
<td>Red Mulberry (Morus rubra)</td>
<td></td>
</tr>
<tr>
<td>Dwarf Palmetto (Sabal minor)</td>
<td></td>
</tr>
<tr>
<td>Soapberry (Sapindus drummondii)</td>
<td></td>
</tr>
<tr>
<td>Sycamore (Platanus occidentalis)</td>
<td></td>
</tr>
</tbody>
</table>

Grasses

<table>
<thead>
<tr>
<th>Forbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalo Grass (Buchloe dactyloides)</td>
</tr>
<tr>
<td>Eastern Gamagrass (Tripsacum dactyloides)</td>
</tr>
<tr>
<td>Green Sprangletop (Leptochloa dubia)</td>
</tr>
<tr>
<td>Prairie Wildrye (Elymus canadensis)</td>
</tr>
<tr>
<td>Switchgrass (Panicum virgatum)</td>
</tr>
<tr>
<td>Little Bluestem (Schizachyrium scoparium)</td>
</tr>
<tr>
<td>Blue Grama (Bouteloua gracilis)</td>
</tr>
<tr>
<td>Sideoats Grama (Bouteloua curtipendula)</td>
</tr>
<tr>
<td>Curly Mesquite (Hilaria belangeri)</td>
</tr>
<tr>
<td>Indiangrass (Sorghastrum nutans)</td>
</tr>
<tr>
<td>Texas Cupgrass (Eriochloa sericea)</td>
</tr>
</tbody>
</table>
Table 5. Candidate riparian plantings

<table>
<thead>
<tr>
<th>Trees and Shrubs</th>
<th>Herbaceous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Dropseed (<em>Sporobolus cryptandrus</em>)</td>
<td></td>
</tr>
<tr>
<td>Sand Lovegrass (<em>Eragrostis trichodes</em>)</td>
<td></td>
</tr>
<tr>
<td>Big Bluestem (<em>Andropogon gerardii</em>)</td>
<td></td>
</tr>
<tr>
<td>Cane Bluestem (<em>Bothriochloa barbinodis</em>)</td>
<td></td>
</tr>
<tr>
<td>White Tridens (<em>Triden albescens</em>)</td>
<td></td>
</tr>
<tr>
<td>Western Wheatgrass (<em>Pascopyrum smithii</em>)</td>
<td></td>
</tr>
<tr>
<td>Bushy Bluestem (<em>Andropogon glomeratus</em>)</td>
<td></td>
</tr>
</tbody>
</table>

*Invasive Species Management:*

Non-native riparian vegetation (primarily Elephant Ear [*Colocasia esculenta]*) along the banks of Landa Lake, in the vicinity of Spring Island and along property owned by CCWRD#1 will be treated using an aquatic-approved herbicide. Elephant ears will be treated in small sections to minimize overall herbicide usage and to minimize soil/bank disturbance over large areas.

Monitor areas where non-native plants were removed in previous years. Re-treat and remove re-emergent non-native vegetation.

**Monitoring:**
Previously restored riparian areas will be monitored for the re-emergence of non-native vegetation and success of native plantings. Sediment capture structures will be monitored for effectiveness. Monitor native riparian plantings for success. A riparian assessment will be conducted twice annually in Spring and Fall to evaluate the condition of the riparian zone.

**Budget:**
Table 7.1:
$100,000

*Available budget:*  
$75,000 (available budget less than Table 7.1 due to funds utilized to fund the Bank Stabilization Project in 2016)

*Estimated 2020 budget:*  
$125,000* (Funds from Task 5.2.6 [$50,000] will be reallocated to fund a portion of Task 5.7.1.)
5.7.5 Management of Household Hazardous Wastes

**Long-term Objective:**
To minimize the potential for improper disposal of hazardous wastes and associated negative impacts to endangered species in the Comal River system.

**Target for 2020:**
Hold three household hazardous waste (HHW) collection events in New Braunfels. Continue to partner with New Braunfels Utilities (NBU) on the Operation MedSafe drug recovery program.

**Methods:**
Conduct three HHW collection events that incorporate an education and outreach component. The HHW events are coordinated by City’s Solid Waste Division in conjunction with Comal County. Each HHW event costs approximately $40,000-$45,000 which includes event set-up and HHW disposal costs. The cost of the first two HHW events is shared evenly between the City and Comal County. The third event is funded largely by the EAHCP ($38,000) with the remaining cost paid for by the City.

The HHW collection events are held at the New Braunfels City Hall. Hazardous waste that is collected during the HHW collection events will be hauled off and disposed of by Clean Harbors.

The City is continuing to explore the feasibility of implementing a HHW drop-off facility that will accept HHW on an ongoing basis throughout the year. Currently, it is expected that a HHW drop-off facility will be opened within three years. The facility will likely be open to the public 1-2 days/week for the drop-off of HHW.

The New Braunfels Police Department partners with NBU to host an annual medicine drop-off event in New Braunfels. The CONB website also contains information about the Operation MedSafe event and tips on proper disposal of medications and drugs.

The EAHCP adaptive management process may be initiated in future years to consider changes to the EAHCP with respect to management of HHW in New Braunfels.

**Monitoring:**
The volume of hazardous waste material collected and the number of participants for each HHW collection event will be documented.

**Budget:**
*Table 7.1:*
$30,000

**Available budget:**
$30,000

**Estimated 2020 budget:**
$38,000* (increase in budget due to increases in HHW events and disposal costs)

*(Funds from Task 5.2.5 [$8,000] will be reallocated to fund a portion of Task 5.7.5.)*
5.7.6 Impervious Cover/Water Quality Protection

**Long-term Objective:**
To reduce non-point source pollutant discharges to Landa Lake and the Comal River system.

**Target for 2020:**
The City will implement water quality management strategies identified in the *Water Quality Protection Plan (WQPP): Phase I* that was developed in 2017. Specific activities to be completed in 2020 include the design and installation of a bio-retention basin to be located at the New Braunfels’ Utilities (NBU) Headwaters facility to treat and infiltrate stormwater runoff from remaining impervious surfaces. Work in 2020 will also include engineering design for a water quality retrofit project at the Landa Park Aquatic Center parking lot. The project will be designed to treat stormwater runoff from the paved parking area using green stormwater infrastructure such as bio-retention and/or permeable parking.

**Methods:**
The WQPP that was developed in 2017 includes evaluation criteria for seven water quality retrofit projects within the Comal River watershed as well as recommendations for implementing water quality improvement projects in conjunction with the construction and development of NBU Headwaters facility located along the banks of the confluence of Bleders Creek and the Upper Spring Run of Landa Lake.

The City will work with NBU and the Headwaters facility to design and construct a bio-retention stormwater treatment basin at NBUs well yard located on the premises of the Headwaters at the Comal facility (*Figure 8*). The project will involve removal of existing asphalt pavement. The existing asphalt pavement will be replaced with a bio-retention basin designed to infiltrate and treat stormwater runoff prior to entering the Upper Spring Run of Landa Lake. NBU and the Headwaters facility will assume responsibility of ongoing maintenance of the stormwater facility to ensure maximum sediment and pollutant removal.

The City will contract with a design engineer to develop plans for green stormwater infrastructure to be incorporated into the Landa Park Aquatics Center parking lot. Green stormwater infrastructure, such as linear bio-retention basins and permeable pavers, would be designed to treat and infiltrate stormwater runoff from the paved parking area prior to discharging to the Comal River which is immediately adjacent to the parking area.
Figure 8. Map indicating the location of the proposed bio-retention stormwater treatment basin within NBUs well yard located on the premises of the Headwaters facility.

Budget:

Table 7.1:

$100,000

Available budget:

$100,000

Estimated 2020 budget:

$155,000*

* $100,000 for design and construction of the bioretention basins at the Headwaters at the Comal facility and $55,000 for engineering design for green stormwater retrofit project at Landa Park Aquatics Center parking lot.